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WATER AND SEDIMENT QUALITY IN THE KAMINISTIQUIA RIVER DELTA AND NEARSHORE AREA OF LAKE SUPERIOR

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WATER AND SEDIMENT QUALITY IN THE KAMINISTIQUIA RIVER DELTA AND NEARSHORE AREA OF LAKE SUPERIOR

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EXECUTIVE SUMMARY

Survey Design

The 1987 Great Lakes Water Quality Board Report to the International Joint Commission (IJC) identifies Thunder Bay as one of four Canadian Areas of Concern in Lake Superior (IJC 1987). The Kaministiquia River system is the largest single source of water-borne contaminants to Thunder Bay harbour and the nearshore area. Although the river receives various minor discharges (including sewers), effluent from the Canadian Pacific Forest Products (CPFP) pulp and paper mill complex approximately 10 km upstream from the river mouth is the dominant point source.

The Great Lakes Section water and sediment investigations in the Kaministiquia River delta and nearshore area during 1985/86 were designed to provide a quantitative assessment of the impacts of flows from the Kaministiquia River on the nearshore environment. This assessment was intended to assist in the derivation of receiving water based effluent limits at industrial discharges as part of the MISA Pilot Site Investigation, and to provide guidance to the Remedial Action Plan (RAP) Team in the design of an adequate surveillance plan to track the effectiveness of abatement actions.

The specific objectives were to: (a) quantify the extent of temperature, turbidity, and water quality stratification occurring in the zone where the Kaministiquia River flows into Lake Superior, (b) document water quality parameters occurring in excess of PWQO in the zone affected by flows from the Kaministiquia River, (c) quantify spatial and temporal variability in water and sediment quality in the delta and nearshore area , and (d) characterize the physical and chemical nature of suspended sediments in the Kaministiquia River upstream and downstream from CPFP.

Water quality sampling for physical parameters, nutrients, trace metals, resin/fatty/aromatic acids (RFAs), organochlorines, chlorobenzenes, chlorophenols, and phenoxy acids was undertaken at nine stations throughout the study area from the top of the delta to the offshore waters of the bay. Sampling took place on two days in the late spring (late May, early June) and two days in mid August during both 1985 and 1986.

Surficial sediment sampling for physical parameters, nutrients, trace metals, and organochlorines was completed at five stations in the delta and nearshore area. Sampling was performed on one day in the late spring and one day in mid August. Suspended sediments were collected with a centrifuge (for the same analyses as surficial sediments) upstream from the CPFP complex, and downstream at the top of the delta. Whole water composite

samples were also obtained from the pre-centrifuge stream at hourly intervals during each sampling period (for the same analyses as other water samples). Centrifuge sampling was undertaken at each station on one day in the late spring and one day in mid August during both 1985 and 1986.

Water Quality Results

Apart from some enhancement of naturally high iron concentrations in the lower river and delta, metals in water presented no reason for concern. Localized nutrient enrichment was evident but also presented no reason for concern. The detection of several organochlorine compounds did not appear to be related to industrial point source discharges in Thunder Bay. The most significant water quality finding was the detection of dehydroabietic acid (DHA) at river mouth stations. Apart from grossly elevated concentrations at the mouth of the Mission River on August 16, 1985 (which may have been attributable to an irregular or accidental discharge) the pattern of concentrations in excess of the toxicity-based PWQO suggests that the capacity of the lower Kaministiquia River to dilute DHA concentrations to acceptable levels was not consistently equal to the loads being discharged to it.

A similarity between the pattern of temperature profiles and turbidity profiles was observed, suggesting that thermal density gradients resulted in poor mixing of river and open-lake water. This created an extensive zone of turbid surface water emanating from the delta where water quality was poor relative to subsurface conditions.

There was a tendency for conductivity, ammonia, total P, and TKN to exhibit maximum concentrations at the mouth of the Kaministiquia River rather than the top of the delta which suggests that the STP discharge immediately upstream from the river mouth was having a measurable effect on water quality. Spring to summer increases in concentrations of conventional parameters were observed at the river mouth stations. These may have been caused by a combination of many factors including seasonal (or daily) increases in effluent discharges to the river. However, reduced flow in the river was likely to have been a prime cause since the August 1986 data were obtained during a period when low flow conditions were artificially maintained in the Kaministiquia River and since results from the lower river and river mouths showed the concentration increase most prominently.

Interaction between station and survey effects was observed for several of the conventional parameters demonstrating that a reliable, quantitative description of differences between station contaminant means cannot be made on the basis of a single season

survey. Conversely, seasonal differences cannot be assessed on the basis of just one station.

Sediment Quality Results

Concentrations of metals in sediments throughout the study area were routinely in excess of Provincial dredging guidelines. Such concentrations are, however, typical of those generally found in sediments of the northern Lake Superior basin and, in the absence of appropriate biological data, cannot be interpreted as identifying a cause for concern. Generally, maximum concentrations occurred at the deeper stations two kilometres and four kilometres offshore while minimum concentrations were found at the mouth of the Kaministiquia River Particle sizes followed a similar pattern with the finest-grained material at the offshore stations, and the coarsest at the mouth of the Kaministiquia River.

Comparison of station means following a grain size correction for metals (to diminish the effect of sediment transport and deposition on sediment chemistry) identified the mouth of the Kaministiquia River and the station four kilometres offshore as being the closest to sources of metals. Average metals concentrations tended to decrease from the spring to summer surveys, however, the opposite trend was apparent for grain size corrected results. This suggests that seasonal changes in sediment composition may mask changes in contaminant concentrations attributable to discharges.

Interaction between station and survey effects was also observed for several parameters, particularly for bulk chemistry (uncorrected) results. Further interpretation of spatial and seasonal variability is, therefore, inappropriate since seasonal shifts were not consistent across all stations.

Centrifuged Water and Sediment Results

Whole water samples obtained during centrifuging showed consistent increases in concentrations of suspended solids, conductivity, alkalinity, sulphate, sodium, total P, TKN, ammonia, aluminum, chromium, iron, zinc, and dehydroabietic acid (and a decrease in pH) over the lower river. A similar comparison of centrifuged particulate chemistry showed consistent increases in percentage loss on ignition, TOC, solvent extractables, cadmium, chromium, copper, mercury, zinc, PCBs, dieldrin, and endrin. Aluminum and nickel concentrations decreased. This combination of increased quantities of suspended solids containing increased contaminant concentrations suggests that particulate loadings of contaminants may have accounted for much of the deterioration in water quality.

Recommendations

(1) Characterization of water quality at stations in the nearshore area requires an appropriate way of eliminating or accommodating the effect of the zone of turbid surface water emanating from the delta, where water quality is poor relative to subsurface conditions. The application of water quality models must also address this effect. Depending upon the specific objectives of the investigation this may be achieved by obtaining depth-integrated samples, or by separate sampling in the epilimnion and hypolimnion.

(2) The variability among seasonal and station contaminant concentration means, and the interaction between them, must be taken into account in the design of future monitoring efforts in the Kaministiquia River delta area. Future water quality surveys undertaken as part of the RAP surveillance plan should stratify sampling to ensure the greatest spatial coverage in the delta and nearshore area with samples taken at more than one depth. Since the ability to discern temporal trends will be masked by high variability a sampling strategy incorporating a combination of weekly sampling at the top of the delta with monthly sampling approximately 4 km offshore may prove most useful.

(3) The elevated metals concentrations found in sediment samples throughout the study area illustrate the interpretational limitations of dredging guidelines, since these concentrations are typical of those generally found in sediments of the northern Lake Superior basin. In order to develop a scientifically defensible management strategy for contaminated sediment, further biological investigations (e.g. benthic enumeration, sediment bioassays) will be required to identify zones having an adverse impact on the aquatic ecosystem either through toxicity (acute and chronic) to benthos, or through food web effects.

(4) In order to establish a link between upstream pulp mill effluent discharges and sediments in the nearshore zone, it will be necessary in future to routinely analyze sediment samples for chlorophenols and resin, fatty, and aromatic acids (analyses not available for this study). Future development of biologically based sediment quality guidelines should recognize the need for pulp and paper related parameters.

(5) Future RAP surveillance investigations monitoring long-term improvements in sediment quality as the result of source controls should make separate comparisons for the delta area and offshore depositional zones and should obtain core samples to provide additional information concerning

temporal variability. Preliminary sampling involving monthly collection of samples from the top of the delta and offshore for physical parameters such as particle size and percentage loss on ignition may prove helpful in the detailed design of such a study.

(6) Additional laboratory analysis of sediment samples following separation of the fine-grained material (i.e. the fraction less than 63 um) will help isolate temporal and spatial changes in sediment quality related to factors other than changes in depositional environment and should be considered to demonstrate the effectiveness of abatement programs at point sources.

(7) Additional centrifuge sampling at the Highway 61 bridge and the top of the delta in the lower river is required to develop sufficient sample sizes to quantify estimates of aqueous-particulate partitioning and loadings of hydrophobic contaminants. Future sampling should also include effluent streams at major point sources in the lower river in order to demonstrate their relative contributions.

(8) Future effluent sampling at CPFP should include those parameters which were detected in excess of the PWQO in order to confirm the source. A demonstration that net loadings of total phosphorus, copper, iron, zinc, and Resin/Fatty/Aromatic acids from CPFP are causing unacceptable water quality in the delta and nearshore area 10 km downstream will form a strong basis for developing receiving water based effluent limits.

1. INTRODUCTION

1.1 Background

The 1987 Great Lakes Water Quality Board Report to the International Joint Commission (IJC) identifies Thunder Bay as one of four Canadian Areas of Concern in Lake Superior (IJC 1987). The degradation of environmental quality is attributed to discharges chiefly from forest products industries and, to a lesser extent, from municipal waste water treatment facilities.

There are eight major industrial point sources of contaminants to Thunder Bay: four pulp and paper mills, a wood preserving operation, a thermal generating station, a chemical manufacturer, and a flour processing plant. There is also a primary sewage treatment plant (STP) with phosphorus removal which discharges at the mouth of the Kaministiquia River. Further detail concerning industrial dischargers throughout the Thunder Bay area is contained in previous Ministry reports (Anderson 1986, Polak 1976, Ontario Ministry of the Environment 1972) and summaries prepared by the Thunder Bay Remedial Action Plan (RAP) team (Vander Wal et al. 1987, 1989).

The Kaministiquia River system is the largest single source of water-borne contaminants to Thunder Bay harbour and the nearshore area. Although the river receives various minor discharges (including sewers), effluent from the Canadian Pacific Forest Products (CPFP)[1] pulp and paper mill complex approximately 10 km upstream from the river mouth is the dominant point source. Effluent from this source depletes oxygen in the lower river as the result of high BOD discharges (Klose 1988) and is responsible for the detection of pulp and paper related compounds such as resin, fatty, and aromatic acids downstream.

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[1] Formerly "Great Lakes Forest Products"

Water quality investigations in 1983 found decreasing gradients of nutrients, metals, organic compounds, and bacteria radiating from the Kaministiquia River delta (Anderson 1986). Provincial Water Quality Objectives (PWQO) (MOE 1984) were occasionally exceeded for PCBs, iron, aluminum, cadmium, and copper. The presence of chlorophenols and other pulp and paper related compounds suggested local mills as a contributing source of the nearshore zone of influence (Anderson 1986).

Results of a 1979 sediment survey in the lower Kaministiqia River and across the harbour showed sediments in the northern harbour to have the highest concentrations of total phenolics, total resin acids, trace metals (copper, mercury, lead, zinc), organochlorine compounds (PCBs, p,p-DDE, lindane) and solvent extractables (Anderson 1986). Sediments at one or more of the river mouths, while not as contaminated, exceeded MOE dredging guidelines (Persaud and Wilkins 1976) for chromium, copper, nickel, zinc, and PCBs.

1.2 Survey Objectives

The 1985 and 1986 water and sediment investigations in the Kaministiquia River delta and nearshore area were designed to follow up the 1983 study (Anderson 1986) by providing a more quantitative assessment of the nearshore impacts caused by the outflow of the Kaministiquia River.

(a) The first objective was to quantify the extent of temperature, turbidity, and water quality stratification occurring in the zone where the Kaministiquia River flows into Lake Superior. Given the relative temperature differences between the river water and open lake, much of the water quality effect observed in the 1983 may have been

confined to a surface layer, and the 1985/86 survey was designed to investigate this.

(b) The second objective was to document the extent to which water quality in the zone affected by flows from the Kaministiquia River failed to meet PWQO. Contaminant concentrations in excess of PWQO provide a direct demonstration of unacceptable water quality conditions resulting from discharges to the Kaministiquia River and this survey was intended to measure the scale of these conditions.

(c) The third objective was to quantify spatial and temporal variability in water and sediment quality in the delta and nearshore area. One of the requirements for the Thunder Bay RAP is the design of an appropriate surveillance plan to track the effectiveness of abatement activity throughout the Area of Concern. A quantitative assessment of existing variability is necessary to allow a meaningful demonstration of improvements in environmental conditions.

(d) The final objective was characterize the physical and chemical nature of suspended sediments in the Kaministiquia River upstream and downstream from CPFP (at the top of the delta). Suspended solids in the final effluent from the CPFP discharges are presumed to be one of the chief sources of contaminated sediment deposited in the delta and nearshore area and a comparison of upstream and downstream suspended sediment provides an indirect measurement of particulate contaminant loadings from the mill. This information will provide a means of estimating downstream water and sediment quality improvements resulting from any future reductions in particulate loadings or improvements in suspended sediment chemistry.

2. SURVEY DESCRIPTION AND METHODS

2.1 Survey Description

Water quality sampling for physical parameters, nutrients, trace metals, resin/fatty/aromatic acids (RFAs), organochlorines, chlorobenzenes, chlorophenols, and phenoxy acids (see Appendix A for complete listing) was undertaken at nine stations throughout the study area from the top of the delta to the offshore waters of the bay (Figure 2.1 and Table 2.1). The river mouth stations were selected arbitrarily, while nearshore and offshore stations were randomly selected from the 1983 station grid. Two successive replicate samples were obtained from the depth of maximum turbidity at the four stations furthest from the delta, and from both the depth of maximum and minimum turbidity at the remaining five stations. Sampling took place on two days in the late spring (late May, early June) and two days in mid August during both 1985 and 1986. This was designed to allow quantification of spatial and temporal variability based on the most turbid water at each location while allowing a comparison of differences in water quality between the depths of minimum and maximum turbidity. Temperature and turbidity profiles were also measured at these nine locations, and additional profiling was completed at 1 km intervals along transects extending from the river mouths.

Surficial sediment sampling for physical parameters, nutrients, trace metals, and organochlorines (see Appendix B for complete listing) was completed at five stations randomly selected from the water quality station list (Figure 2.1, Table 2.1). Two successive replicates were obtained so that a quantitative assessment of spatial and temporal variability could be undertaken. Sampling was performed on one day in the late spring and one day in the late fall.

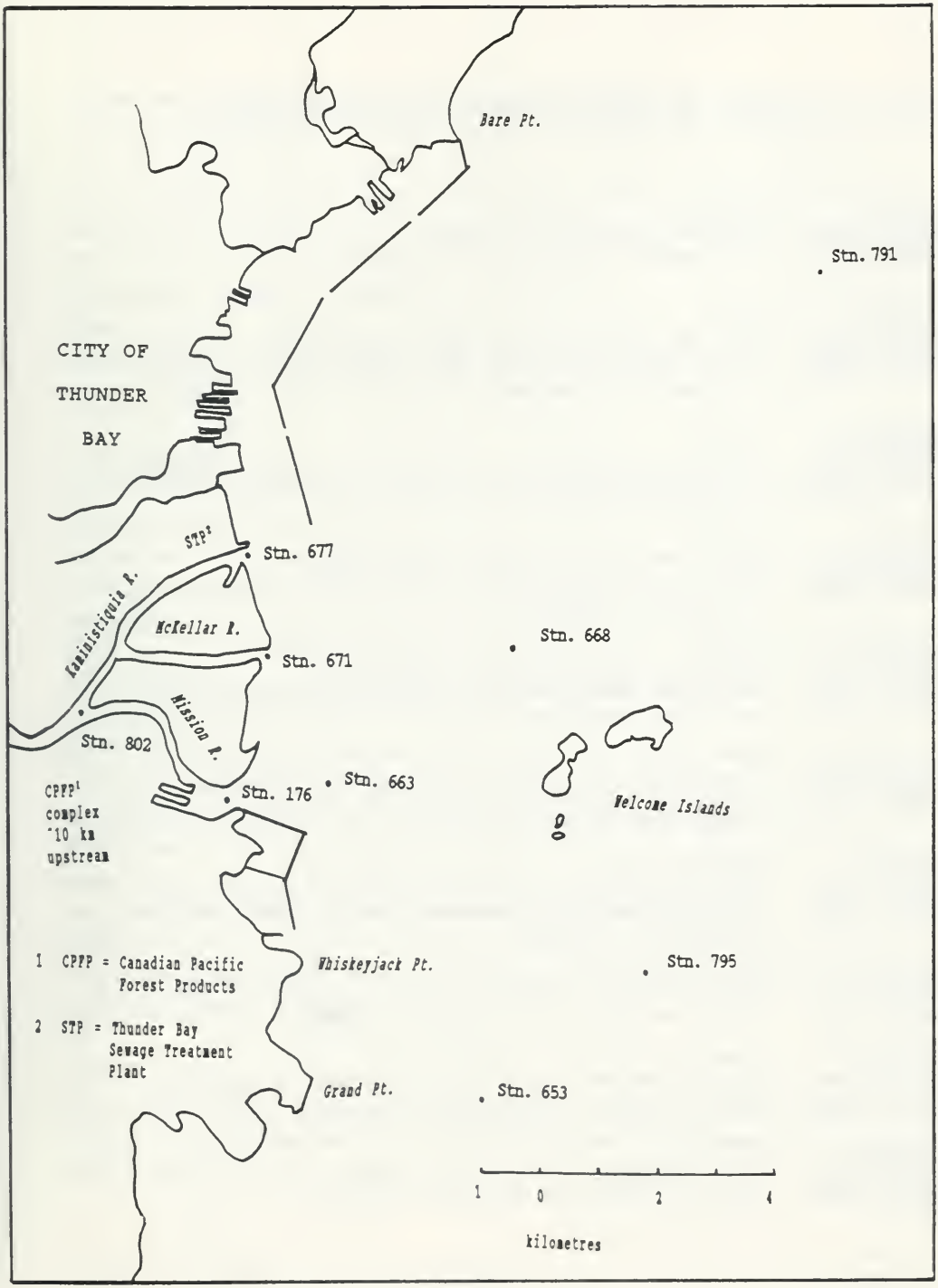


Figure 2.1 Thunder Bay Nearshore Sampling Locations 1985/86

TABLE 2.1: THUNDER BAY NEARSHORE STUDY SAMPLING STATIONS

STATION: 15-0009
DESCRIPTION: Kam. R. at Hwy. 61 bridge
SAMPLE TYPE: Suspended sediment near surface

STATION: 0802
DESCRIPTION: Top of Kam. R. delta (depth 9m)
SAMPLE TYPE: Water at depth of maximum turbidity, suspended sediment near surface.

STATION: 0677
DESCRIPTION: Mouth of the Kam. R. (depth 10m)
SAMPLE TYPE: Water at depths of maximum and minimum turbidity, surficial sediment.

STATION: 0671
DESCRIPTION: Mouth of the McKellar R. (depth 6m)
SAMPLE TYPE: Water at depths of maximum and minimum turbidity, surficial sediment.

STATION: 0176
DESCRIPTION: Mouth of the Mission R. (depth 9m)
SAMPLE TYPE: Water at depths of maximum and minimum turbidity, surficial sediment.

STATION: 0663
DESCRIPTION: 2 km offshore from the Mission R. (depth 9m)
SAMPLE TYPE: Water at depths of maximum and minimum turbidity, surficial sediment.

STATION: 0668
DESCRIPTION: 4 km offshore from the McKellar R. (depth 16m)
SAMPLE TYPE: Water at depths of maximum and minimum turbidity, surficial sediment.

STATION: 0653
DESCRIPTION: 3 km offshore from Grand Pt. (depth 29m)
SAMPLE TYPE: Water at depth of maximum turbidity.

STATION: 0795
DESCRIPTION: 6 km offshore from Whiskeyjack Pt. (depth 32m)
SAMPLE TYPE: Water at depth of maximum turbidity.

STATION: 0791
DESCRIPTION: 6 km offshore from Bare Pt. (depth 43 m)
SAMPLE TYPE: Water at depth of maximum turbidity.

Suspended sediments were collected (for the same analyses as surficial sediments) at the Highway 61 (Hwy. 61) bridge, and at the top of the delta. Samples were collected from a depth of approximately 1 m and were concentrated with a centrifuge until a minimum of 50 g of material (wet weight) had been obtained. Whole water composite samples were also obtained from the pre-centrifuge stream at hourly intervals during each sampling period (for the same analyses as other water samples). Centrifuge sampling was undertaken at each station on one day in the late spring and one day in mid August during both 1985 and 1986.

2.2 Field Methods

Water column profiles of temperature and turbidity (percentage transmittance) were obtained with a Moniteq MTR 25 transmissometer package comprising a 25 cm path length transmissometer calibrated to 75% in air, a temperature probe, a pressure transducer (for depth measurement), and an X-Y chart recorder. Continuous turbidity profiles were recorded while lowering the instrument sonde, and temperature profiles were recorded while raising the sonde. This procedure was adopted in order to prevent measurement of turbidity peaks caused by the sonde coming in contact with the lake bed. Reading errors of $\pm$ 0.5 m for depth, $\pm$ 5% transmittance for turbidity, and $\pm$ 1.0 $^{\circ}$C for temperature were estimated based on comparison of duplicate profiles. Due to equipment failure, profiling in this manner was not possible during the spring 1986 survey. Instead, temperature profiles were obtained by taking discrete temperature readings at 1 m intervals using a YSI 406 thermistor, and no turbidity profiles were obtained.

Water samples were pumped from the desired depth using a March 5CMD submersible pump and teflon hose. Sample containers were filled, preserved (where appropriate), and stored according to MOE standard methods (MOE 1985) for the required range of tests.

Field blanks for metals and organics QA/QC were obtained by pouring double distilled water through the pump-hose system. Split samples were also obtained at two randomly selected stations during each survey, in order to ensure that the replication in the survey design adequately incorporated field sampling error.

Sediment grab samples were obtained with a Shipek dredge sampler. The surface 3 cm of sediment were removed and homogenized using a stainless steel spatula and a hexane rinsed, glass dish. Sample containers were filled and stored for the required range of tests according to MOE standard methods (MOE 1985). A split sample was obtained for QA/QC purposes at one randomly selected station during each survey.

Suspended sediments were pumped using the same pump-hose system employed for water sampling and were concentrated with a continuous flow Alfa Laval 103B centrifuge at a rate of approximately six litres per minute. The collected sediments were transferred to appropriate containers with a stainless steel scraper and stored in the dark at 4 °C for the required range of tests according to MOE standard methods (MOE 1985). The composite sample of pre-centrifuged water was handled in the same manner as other water samples.

2.3 Laboratory Methods

Water quality analyses were undertaken by the MOE Thunder Bay Regional Laboratory, and by the Water Quality, Inorganic Trace Contaminant, Drinking Water Organics, and Trace Organics Sections at the MOE Laboratory Services Branch according to standard MOE analytical methods (MOE 1983). Sediments and suspended sediments were analyzed by the Inorganic Trace Contaminants and Trace Organics Sections of the Laboratory Services Branch according to MOE standard methods (MOE 1983). Particle size analyses were

undertaken using two Leeds and Northrup Microtrac$_{TM}$ particle size analyzers.

3. RESULTS AND DISCUSSION

3.1 Temperature and Turbidity Profiling

Results of temperature and turbidity profiling at water quality stations are summarized in Tables 3.1 and 3.2 respectively. Additional results from temperature and turbidity profiling transect stations are displayed in Figures 3.1 to 3.7.

Temperature profiling results from the late spring show water column temperature ranges of at least 5 °C for river mouth stations, with weak or no vertical gradients at intermediate and offshore stations (Table 3.1). By mid August, however, all stations showed relatively strong vertical temperature gradients with ranges of 7 °C present at even the offshore stations. Results from the nearshore transect stations (Figures 3.1 to 3.5) also illustrate the contrast between late spring and mid August. In the late spring the open lake can be seen to be cold (~7 °C) and isothermal with vertical temperature gradients confined to within 3 km of the river mouths. By mid August, however, stratification was visible at even the most remote stations although surface water temperatures in the vicinity of the delta remained approximately 5 °C warmer than those offshore.

Turbidity profiling results at water quality stations (Table 3.2) show non-uniform profiles near the river mouths with elevated surface turbidity (i.e. low % transmittance). The deep water stations furthest offshore show relatively uniform profiles and the intermediate stations fall in between these two extremes with weakly, non-uniform profiles. Transect profiling results (Figures 3.1 to 3.5) provide better resolution of the nearshore

turbid zone. These clearly show a zone of high surface turbidity at the river mouths, weakening with both distance offshore and depth below the surface. Surface turbidity reached ambient levels and vertical turbidity gradients dissipated within 2 to 5 km offshore from the river mouths.

3.2 Water Quality Sampling

A list of the 91 tests performed on water quality samples appears in Appendix A. Results for physical parameters, nutrients, and selected trace metals have been summarized for each parameter to show the concentration range, mean and standard deviation (where appropriate), and median at each station (Tables 3.2.1 to 3.2.12). These tables also indicate the percentage of samples with concentrations greater than the minimum reportable amount (MRA): a detection level concentration determined at the laboratory which incorporates equipment sensitivity and precision as well as variability associated with sample preparation. Where relevant, the summary tables also show the percentage of sample concentrations greater than the Provincial Water Quality Objectives (PWQO). A complete listing of all water quality data is included in Appendix B.

Results of analyses for resin, fatty, and aromatic acids (RFAs) have been listed in Table 3.2.13, while organochlorines, chlorophenols, chlorobenzenes, and phenoxy acids data appear in Table 3.2.14. These tables list only those compounds detected above the MRA on at least one occasion, at one more stations. Appendix A provides a complete list of all compounds analyzed for.

3.2.1 Physical Parameters and Nutrients in Water

Maximum median concentrations of 5-day biochemical oxygen demand (BOD5), dissolved organic carbon (DOC), and sulphate were detected at the top of the delta (Stn. 802) in samples obtained

TABLE 3.1 THUNDER BAY WATER TEMPERATURE PROFILING SUMMARY -- MAXIMUM AND MINIMUM DEGREES CELSIUS AND CORRESPONDING DEPTHS

STATION		SAMPLING DATES 11/06/85	14/06/85	15/08/85	16/08/85	31/05/86	02/06/86	12/08/86	15/08/86
802	Max.	---	---	---	---	---	17 (0-2m)	19 (0-2m)	21 (0m)
	Min.	---	---	---	---	---	11 ()6m)	15 ()8m)	11 ()6m)
176	Max.	17 (0m)	19 (0m)	19 (0-3m)	17 (0m)	17 (0-2m)	16 (0-2m)	19 (0-3m)	20 (0m)
	Min.	11 (8m)	13 ()7m)	10 (9m)	7 (9m)	9 ()8m)	9 ()8m)	14 ()8m)	9 ()8m)
671	Max.	14 (1m)	14 (0m)	20 (0m)	17 (0-2m)	17 (0m)*	15 (0m)	18 (0m)	18 (0m)
	Min.	9 ()5m)	9 ()4m)	15 (6m)	9 (6m)	7 (6m)*	10 ()5m)	14 ()5m)	10 ()5m)
677	Max.	14 (0m)	16 (1m)	19 (0-2m)	14 (0-2m)	18 (0m)*	15 (0m)	19 (0-2m)	17 (0m)
	Min.	9 ()7m)	9 ()7m)	10 (9m)	7 (9m)	7 ()7m)*	9 ()6m)	12 ()8m)	9 ()8m)
663	Max.	10 (0m)	13 (0m)	15 (0-4m)	14 (0-2m)	---	12 (0-4m)	17 (0-4m)	15 (0-5m)
	Min.	8 ()7m)	9 ()5m)	10 ()8m)	9 (9m)	---	10 ()6m)	13 ()8m)	14 ()7m)
668	Max.	8 (0m)	8 (0m)	17 (0-8m)	15 (0-2m)	9 (all)	9 (all)	17 (0-4m)	16 (0-2m)
	Min.	7 ()5m)	7 ()5m)	9 ()13m)	8 ()12m)	9 (all)	9 (all)	8 ()12m)	10 ()10m)
653	Max.	8 (0m)	11 (0m)	---	14 (0m)	---	10 (all)	17 (0-6m)	15 (0m)
	Min.	7 ()8m)	10 (16m)	---	7 ()11m)	---	10 (all)	8 ()17m)	11 ()11m)
795	Max.	8 (1m)	11 (1m)	---	14 (0-3m)	---	10 (all)	17 (0-10m)	17 (0-3m)
	Min.	6 (22m)	9 (19m)	---	5 ()18m)	---	10 (all)	8 ()17m)	7 ()18m)
791	Max.	6 (0m)	---	15 (0m)	15 (0-3m)	12 (0m)	7 (all)	---	14 (0-3m)
	Min.	5 ()19m)	---	8 ()17m)	7 ()17m)	6 ()6m)	7 (all)	---	7 ()17m)

* indicates that these samples were obtained on 30/05/86

TABLE 3.2 THUNDER BAY WATER CLARITY PROFILING SUMMARY -- MINIMUM AND MAXIMUM % TRANSMITTANCE AND CORRESPONDING DEPTHS

STATION		SAMPLING DATES 11/06/85	14/06/85	15/08/85	16/08/85	31/05/86	02/06/86	12/08/86	15/08/86
802	Min.	---	---	---	---	---	---	(1% (8m)	7% (2m)
	Max.	---	---	---	---	---	---	8% (2m)	34% (7m)
176	Min.	2% (7m)	2% (5m)	23% (2m)	16% (2m)	---	---	18% (2m)	7% (2m)
	Max.	14% (8m)	19% (1m)	61% (8m)	55% (9m)	---	---	32% (6m)	34% (8m)
671	Min.	12% (1m)	21% (4m)	25% (2m)	31% (1m)	---	---	25% (2m)	18% (2m)
	Max.	38% (5m)	45% (5m)	40% (6m)	69% (6m)	---	---	30% (5m)	43% (6m)
677	Min.	18% (1m)	19% (2m)	15% (2m)	72% (8m)	---	---	15% (5m)	16% (2m)
	Max.	40% (7m)	45% (7m)	72% (8m)	88% (1m)	---	---	29% (8m)	49% (5m)
663	Min.	31% (1m)	34% (1m)	48% (5m)	72% (8m)	---	---	42% (2m)	45% (2m)
	Max.	79% (8m)	72% (7m)	76% (1m)	88% (2m)	---	---	46% (5m)	49% (6m)
668	Min.	77% (1m)	86% (5m)	72% (5m)	69% (6m)	---	---	45% (2m)	50% (2m)
	Max.	90% (15m)	92% (14m)	80% (14m)	81% (14m)	---	---	49% (5m)	55% (8m)
653	Min.	82% (1m)	85% (4m)	---	72% (4m)	---	---	42% (9m)	37% (1m)
	Max.	87% (12m)	92% (19m)	---	87% (23m)	---	---	61% (23m)	56% (23m)
795	Min.	84% (4m)	85% (4m)	---	76% (9m)	---	---	50% (2m)	46% (2m)
	Max.	89% (19m)	92% (19m)	---	85% (1m)	---	---	58% (18m)	56% (12m)
791	Min.	92% (all)	---	78% (1m)	84% (9m)	---	---	50% (2m)	48% (2m)
	Max.	92% (all)	---	86% (20m)	89% (1m)	---	---	65% (16m)	64% (22m)

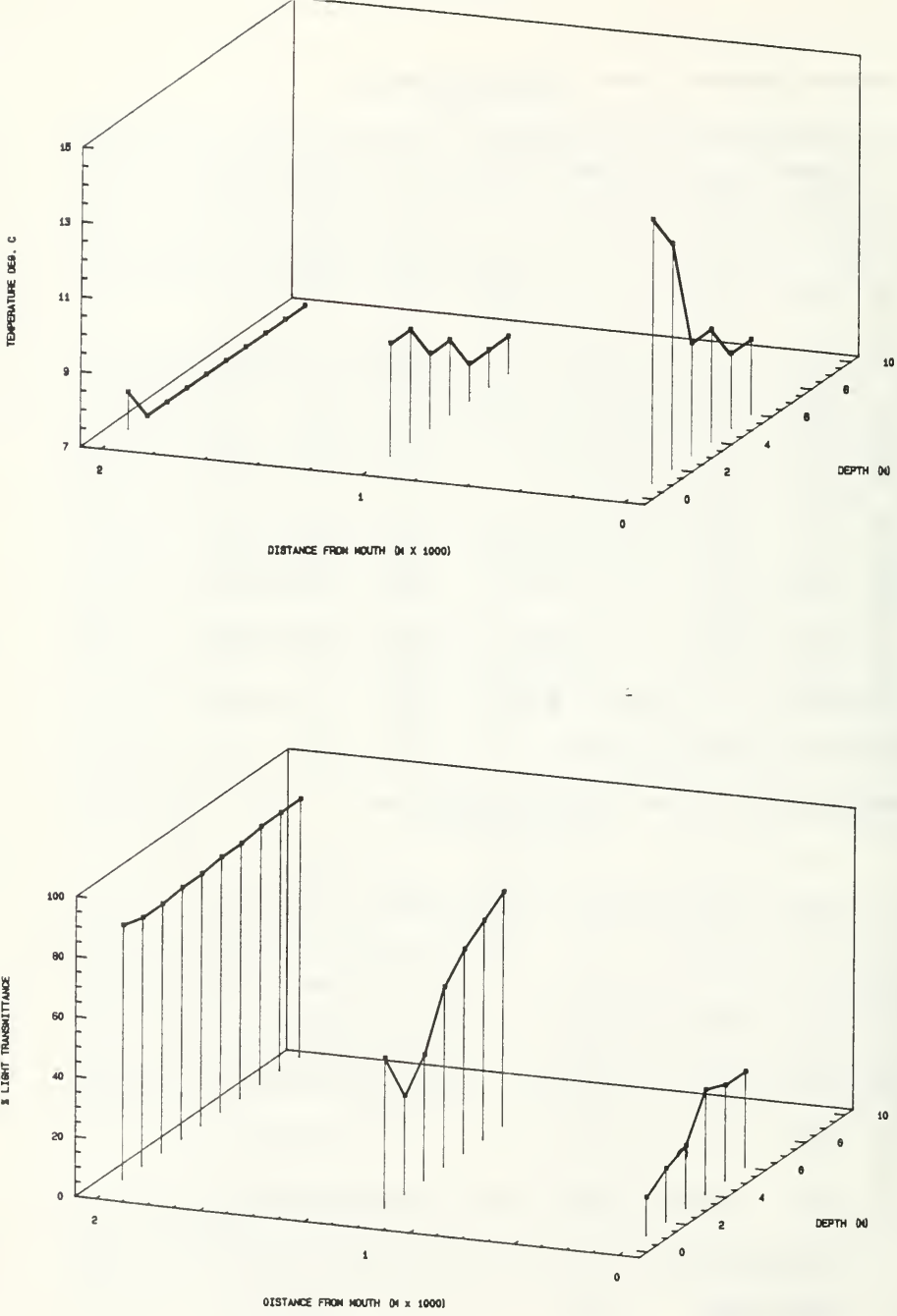


Figure 3.1 Temperature and Turbidity Profiles on June 11, 1985 at the McKellar R. Transect

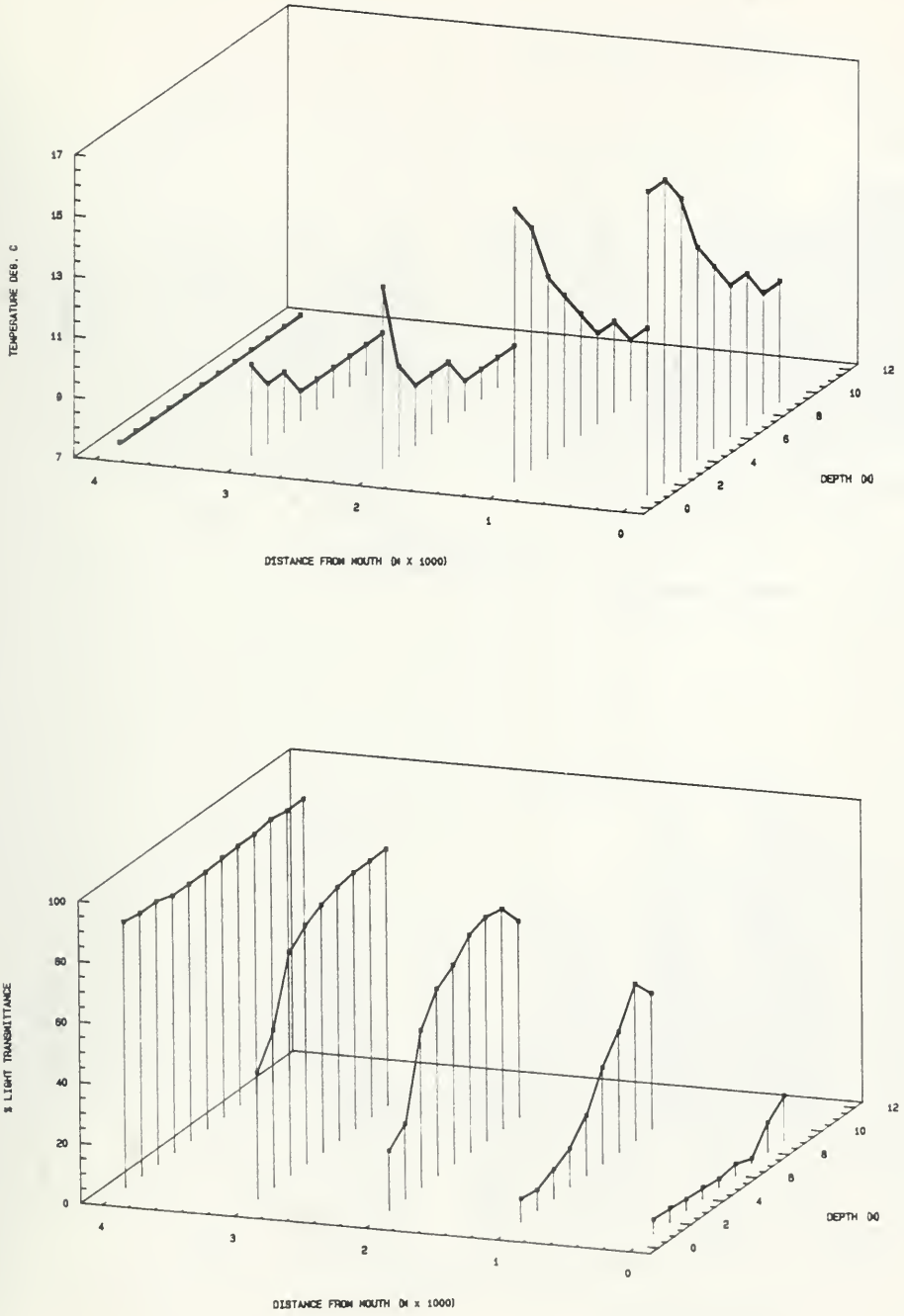
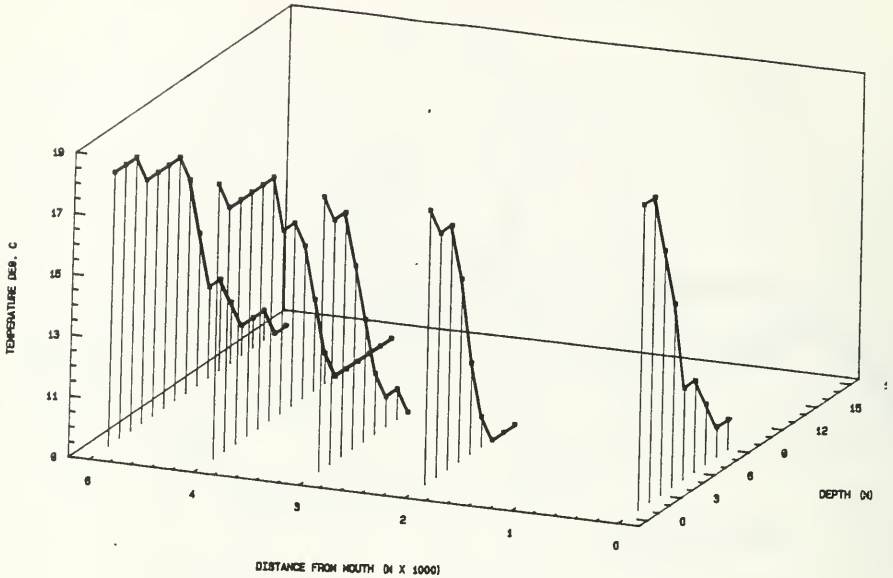


Figure 3.2 Temperature and Turbidity Profiles on June 11, 1985 at the Mission R. Transect



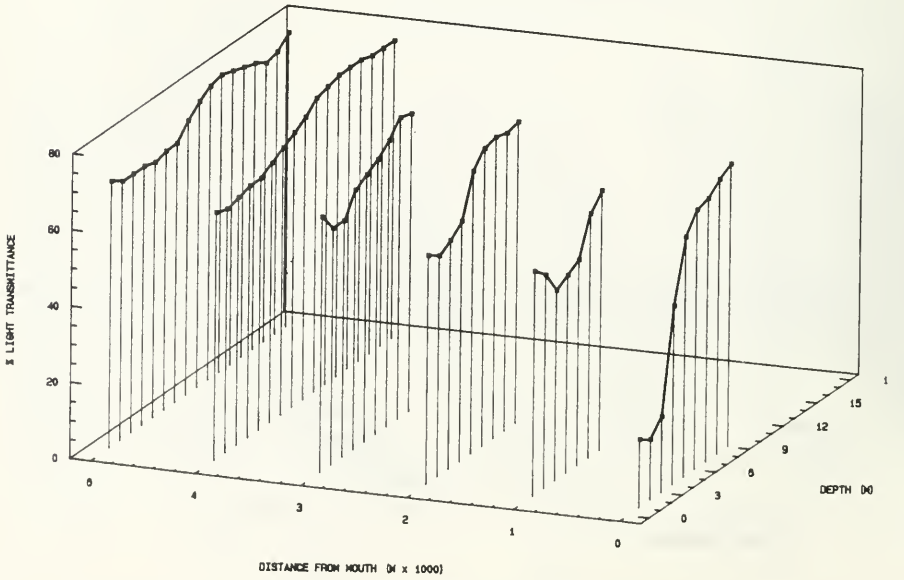
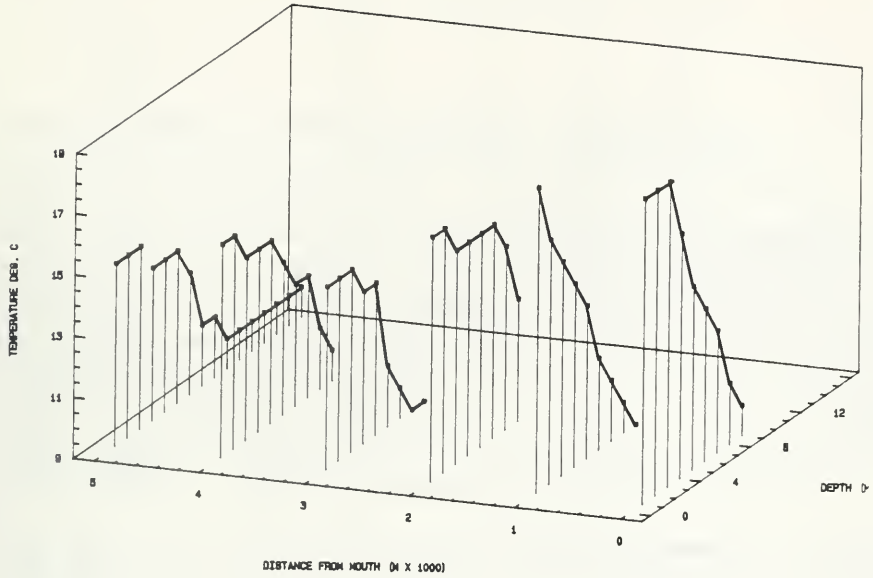


Figure 3.3 Temperature and Turbidity Profiles on August 15, 1985 at the Kaministiquia R. Transect



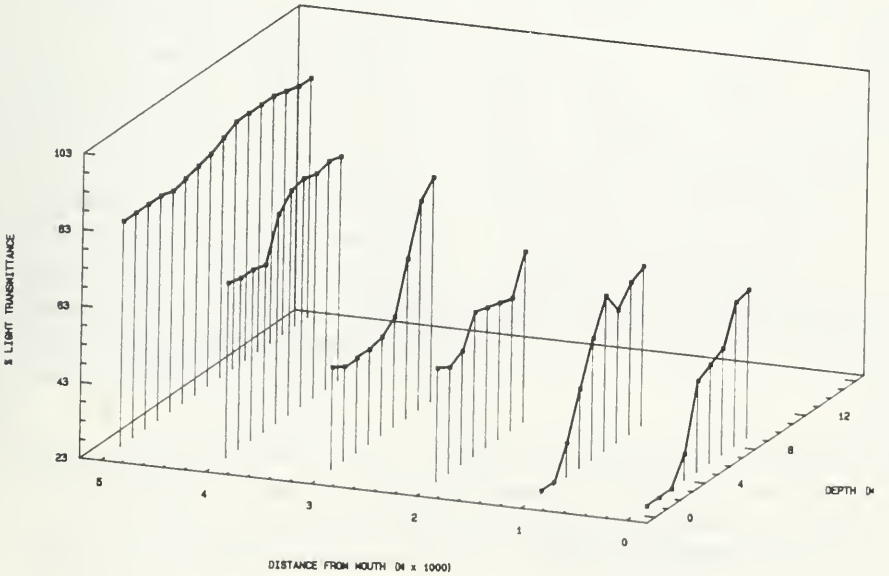
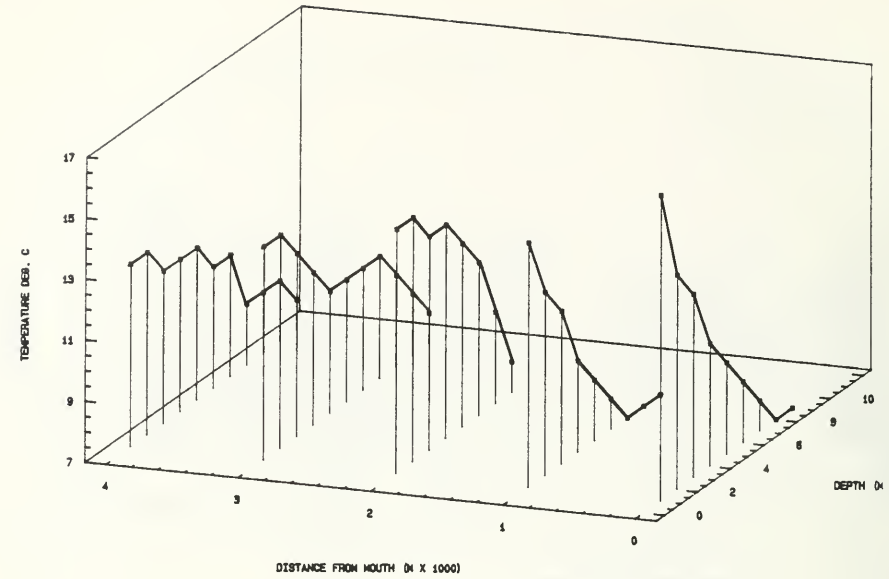


Figure 3.4 Temperature and Turbidity Profiles on August 15, 1985 at the Mission R. Transect



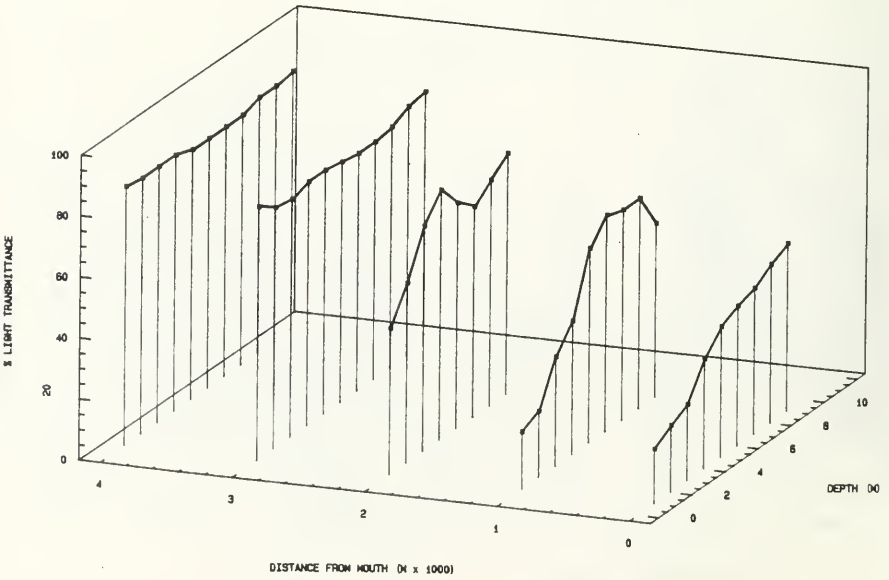


Figure 3.5 Temperature and Turbidity Profiles on August 16, 1985 at the Mission R. Transect

from the depth of maximum turbidity. Maximum median concentrations of 25 °C conductivity (COND25), total ammonia,total phosphorus (TP), and total Kjeldahl Nitrogen (TKN) were observed in the maximum turbidity samples at the mouth of the Kaministiquia River downstream from the STP discharge. Samples from the depth of minimum turbidity throughout the delta area exhibited concentrations of BOD5, COND25, DOC, and sulphate similar to those found in the offshore zone. Concentrations of total ammonia, TP, and TKN in minimum turbidity samples from the delta area were intermediate to the extremes of the offshore zone, and the surface turbid layer within the delta area.

The PWQO of 20 ug l^{-1} of un-ionised ammonia was never exceeded. The maximum total ammonia concentrations observed at the mouth of the Kaministiquia River (1.1 mg l^{-1} in 1985, and 1.9 mg l^{-1} in 1986) corresponded to temperatures of approximately 15 °C and 20 °C with a pH of 7.0 yielding un-ionised ammonia concentrations of approximately 3 ug l^{-1} and 8 ug l^{-1}. Surface water results for TP in the delta area show that the Provincial Guideline (PWQG) of 20 ug l^{-1} was exceeded on all occasions. However, this guideline exists for the prevention of nuisance concentrations of algae and the oligotrophic nature of the receiving water (i.e. less than 5 ug l^{-1} of TP in the offshore zone) ensures that elevated concentrations are rapidly diluted below the guideline concentration and do not result in algal blooms. Algal populations in this region of the Great Lakes have been identified as being potentially more dependent on the light-temperature regime than on the nutrient supply of Lake Superior (Hopkins 1986).

Suspended sediment concentrations in the water column were highly variable despite the generally consistent pattern demonstrated by the turbidity profiling. Although delta stations exhibited median concentrations greater than those found at intermediate or

TABLE 3.2.1 THUNDER BAY 1985/86 WATER QUALITY SUMMARY: BOD5

Results in mg/l P.W.Q.O.: N/A

STATION		N	Range	Mean	S.D.	Median	%>MRA	%>PWQO
802 (Max.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	2.0 to 7.4	3.89	2.09	3.10	100	N/A
176 (Max.Turb.)	1985	4	1.3 to 1.9	1.65	0.25	1.70	100	N/A
	1986	8	1.9 to 4.2	2.46	0.76	2.15	100	N/A
176 (Min.Turb.)	1985	2	0.5 to 0.5	N/A	N/A	N/A	100	N/A
	1986	8	0.3 to 1.2	0.61	0.36	0.55	100	N/A
671 (Max.Turb.)	1985	4	0.9 to 2.0	1.47	0.46	1.50	100	N/A
	1986	8	1.0 to 3.2	1.72	0.73	1.65	100	N/A
671 (Min.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	0.4 to 1.1	0.71	0.23	0.70	100	N/A
677 (Max.Turb.)	1985	4	0.9 to 2.6	2.12	0.82	2.50	100	N/A
	1986	8	1.3 to 4.9	2.82	1.40	2.55	100	N/A
677 (Min.Turb.)	1985	2	0.3 to 0.7	0.50	0.28	0.50	100	N/A
	1986	8	0.4 to 1.0	0.72	0.21	0.75	100	N/A
663 (Max.Turb.)	1985	4	0.3 to 1.0	0.68	0.33	0.70	100	N/A
	1986	8	0.4 to 1.2	0.79	0.30	0.65	100	N/A
663 (Min.Turb.)	1985	4	0.3 to 0.8	0.58	0.26	0.60	100	N/A
	1986	8	0.5 to 0.8	0.66	0.11	0.65	100	N/A
668 (Max.Turb.)	1985	6	0.3 to 0.8	0.45	0.21	0.35	100	N/A
	1986	8	0.2 to 0.6	0.40	0.17	0.40	100	N/A
668 (Min.Turb.)	1985	3	0.2 to 0.6	0.38	0.21	0.50	100	N/A
	1986	8	0.1 to 0.6	0.39	0.22	0.45	100	N/A
653 (Max.Turb.)	1985	7	0.4 to 0.8	0.63	0.14	0.70	100	N/A
	1986	6	0.4 to 0.9	0.60	0.21	0.55	100	N/A
795 (Max.Turb.)	1985	7	0.3 to 0.9	0.69	0.20	0.80	100	N/A
	1986	7	0.4 to 0.7	0.52	0.13	0.50	100	N/A
791 (Max.Turb.)	1985	4	0.2 to 0.6	0.35	0.19	0.30	100	N/A
	1986	7	0.2 to 0.6	0.40	0.14	0.40	100	N/A

M.R.A. = Minimum Reportable Amount

TABLE 3.2.2 THUNDER BAY 1985/86 WATER QUALITY SUMMARY: CONDUCTIVITY 25

Results in uS/cm P.W.Q.O.: N/A

STATION		N	Range	Mean	S.D.	Median	%>MRA	%>PWQO
802 (Max.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	135 to 239	164.4	44.0	145.5	100	N/A
176 (Max.Turb.)	1985	4	128 to 164	139.3	16.7	132.5	100	N/A
	1986	8	126 to 222	164.6	39.3	156.0	100	N/A
176 (Min.Turb.)	1985	2	98 to 99	98.5	0.7	98.5	100	N/A
	1986	8	101 to 158	114.8	22.7	103.5	100	N/A
671 (Max.Turb.)	1985	4	129 to 145	137.3	8.4	137.5	100	N/A
	1986	8	111 to 202	142.2	31.8	134.0	100	N/A
671 (Min.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	104 to 122	109.0	7.5	105.5	100	N/A
677 (Max.Turb.)	1985	4	136 to 192	157.0	24.3	150.0	100	N/A
	1986	8	114 to 196	150.6	32.4	145.5	100	N/A
677 (Min.Turb.)	1985	2	98 to 108	103.0	7.1	103.0	100	N/A
	1986	8	98 to 123	104.9	8.8	101.5	100	N/A
663 (Max.Turb.)	1985	4	98 to 128	109.8	15.0	103.0	100	N/A
	1986	8	100 to 114	105.2	6.2	107.0	100	N/A
663 (Min.Turb.)	1985	4	97 to 116	106.5	3.9	107.5	100	N/A
	1986	8	100 to 106	102.9	2.2	103.0	100	N/A
668 (Max.Turb.)	1985	6	98 to 101	99.8	1.2	100.0	100	N/A
	1986	8	99 to 102	100.1	1.0	100.0	100	N/A
668 (Min.Turb.)	1985	3	98 to 101	99.3	1.5	100.0	100	N/A
	1986	8	99 to 102	99.7	1.2	99.0	100	N/A
653 (Max.Turb.)	1985	7	98 to 104	102.7	2.1	103.0	100	N/A
	1986	6	99 to 103	101.2	1.7	102.0	100	N/A
795 (Max.Turb.)	1985	7	97 to 104	101.3	2.3	102.0	100	N/A
	1986	6	99 to 104	101.5	1.6	101.5	100	N/A
791 (Max.Turb.)	1985	4	97 to 101	98.3	1.9	97.5	100	N/A
	1986	7	97 to 104	99.4	2.7	98.0	100	N/A

M.R.A. = Minimum Reportable Amount

TABLE 3.2.3 THUNDER BAY 1985/86 WATER QUALITY SUMMARY: DISSOLVED ORGANIC CARBON

Results in mg/l P.W.Q.O.: N/A

STATION		N	Range	Mean	S.D.	Median	%>MRA	%>PWQO
802 (Max.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	6.4 to 14.8	12.26	3.47	13.90	100	N/A
176 (Max.Turb.)	1985	4	6.5 to 10.5	9.15	1.80	9.80	100	N/A
	1986	8	10.8 to 13.5	11.86	1.00	11.60	100	N/A
176 (Min.Turb.)	1985	2	2.1 to 2.2	2.15	0.07	2.15	100	N/A
	1986	8	2.5 to 5.5	3.91	1.01	3.75	100	N/A
671 (Max.Turb.)	1985	4	4.1 to 9.7	6.85	2.50	6.80	100	N/A
	1986	8	6.8 to 12.1	8.89	2.01	8.50	100	N/A
671 (Min.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	3.0 to 5.0	3.80	0.79	3.65	100	N/A
677 (Max.Turb.)	1985	4	4.0 to 9.7	7.10	2.60	7.40	100	N/A
	1986	8	5.8 to 10.0	8.01	1.85	8.30	100	N/A
677 (Min.Turb.)	1985	2	1.8 to 3.0	2.40	0.85	2.40	100	N/A
	1986	8	2.1 to 3.9	2.70	0.62	2.55	100	N/A
663 (Max.Turb.)	1985	3	2.0 to 4.2	3.20	1.10	3.40	100	N/A
	1986	8	2.7 to 6.3	3.90	1.51	3.20	100	N/A
663 (Min.Turb.)	1985	3	2.1 to 2.8	2.37	0.38	2.20	100	N/A
	1986	8	2.8 to 3.4	3.13	0.21	3.10	100	N/A
668 (Max.Turb.)	1985	6	1.8 to 2.4	2.10	0.20	2.10	100	N/A
	1986	8	2.7 to 3.5	2.96	0.25	2.95	100	N/A
668 (Min.Turb.)	1985	3	1.6 to 1.8	1.70	0.09	1.60	100	N/A
	1986	8	2.6 to 4.0	2.96	0.45	2.85	100	N/A
653 (Max.Turb.)	1985	7	1.8 to 3.0	2.30	0.40	2.20	100	N/A
	1986	6	2.3 to 6.0	3.07	1.44	2.55	100	N/A
795 (Max.Turb.)	1985	7	1.8 to 2.3	2.10	0.20	2.00	100	N/A
	1986	6	2.4 to 4.6	3.27	0.79	3.15	100	N/A
791 (Max.Turb.)	1985	4	1.6 to 2.3	2.10	0.20	1.70	100	N/A
	1986	6	2.0 to 3.7	2.95	0.71	3.00	100	N/A

M.R.A. = Minimum Reportable Amount

TABLE 3.2.4 THUNDER BAY 1985/86 WATER QUALITY SUMMARY: TOTAL AMMONIA

Results in ug/l P.W.Q.O.: 20 ug/l un-ionised ammonia

STATION		N	Range	Mean	S.D.	Median	%>MRA	%>PWQO
802 (Max.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	10 to 310	122	80	130	100	0
176 (Max.Turb.)	1985	4	20 to 60	40	20	40	100	0
	1986	8	10 to 90	40	36	30	100	0
176 (Min.Turb.)	1985	2	<10 to 30	N/A	N/A	20	50	0
	1986	8	10 to 40	22	10	20	100	0
671 (Max.Turb.)	1985	4	80 to 170	120	38	120	100	0
	1986	8	40 to 180	109	45	120	100	0
671 (Min.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	50 to 160	84	48	65	100	0
677 (Max.Turb.)	1985	4	130 to 1100	395	470	175	100	0
	1986	8	10 to 1900	565	720	260	100	0
677 (Min.Turb.)	1985	2	20 to 30	25	7	25	100	0
	1986	8	10 to 360	79	131	10	100	0
663 (Max.Turb.)	1985	4	<10 to 40	N/A	N/A	14	75	0
	1986	8	<10 to 10	N/A	N/A	10	88	0
663 (Min.Turb.)	1985	4	10 to 20	15	6	15	100	0
	1986	8	<10 to 20	N/A	N/A	10	88	0
668 (Max.Turb.)	1985	6	10 to 20	17	5	20	100	0
	1986	8	10 to 10	N/A	N/A	10	100	0
668 (Min.Turb.)	1985	4	<10 to 20	N/A	N/A	10	50	0
	1986	8	<10 to 10	N/A	N/A	10	75	0
653 (Max.Turb.)	1985	7	10 to 20	11	4	10	100	0
	1986	6	<10 to 10	N/A	N/A	10	83	0
795 (Max.Turb.)	1985	7	<10 to 20	N/A	N/A	10	71	0
	1986	6	10 to 20	12	4	10	100	0
791 (Max.Turb.)	1985	4	<10 to 20	N/A	N/A	20	75	0
	1986	7	10 to 30	13	8	10	100	0

M.R.A. = Minimum Reportable Amount

TABLE 3.2.5 THUNDER BAY 1985/86 WATER QUALITY SUMMARY: SULPHATE

Results in mg/l P.W.Q.O.: N/A

STATION		N	Range	Mean	S.D.	Median	%>MRA	%>PWQO
802 (Max.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	8.6 to 24.3	15.04	5.90	13.45	100	N/A
176 (Max.Turb.)	1985	4	8.1 to 14.3	10.95	2.71	10.72	100	N/A
	1986	8	10.2 to 20.0	14.50	3.91	13.90	100	N/A
176 (Min.Turb.)	1985	2	3.8 to 3.4	3.82	0.02	3.82	100	N/A
	1986	8	4.0 to 8.4	5.27	1.86	4.44	100	N/A
671 (Max.Turb.)	1985	4	6.0 to 11.1	9.26	2.22	9.96	100	N/A
	1986	8	6.7 to 16.8	10.40	3.45	9.86	100	N/A
671 (Min.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	4.1 to 6.9	5.06	1.05	4.80	100	N/A
677 (Max.Turb.)	1985	4	8.2 to 11.1	10.03	1.34	10.45	100	N/A
	1986	8	6.2 to 10.9	9.02	1.71	9.34	100	N/A
677 (Min.Turb.)	1985	2	3.6 to 4.7	4.14	0.84	4.14	100	N/A
	1986	8	3.6 to 5.0	4.09	0.50	3.94	100	N/A
663 (Max.Turb.)	1985	4	3.6 to 6.8	4.78	1.52	3.98	100	N/A
	1986	8	3.7 to 7.0	4.85	1.37	4.41	100	N/A
663 (Min.Turb.)	1985	4	3.6 to 5.0	4.50	0.61	4.67	100	N/A
	1986	8	3.9 to 4.9	4.30	0.37	4.17	100	N/A
668 (Max.Turb.)	1985	6	3.6 to 4.1	3.87	0.19	3.87	100	N/A
	1986	8	3.6 to 4.2	3.90	0.24	3.94	100	N/A
668 (Min.Turb.)	1985	3	3.5 to 3.6	3.56	0.07	3.53	100	N/A
	1986	8	3.7 to 4.1	3.84	0.18	3.80	100	N/A
653 (Max.Turb.)	1985	7	3.6 to 4.4	3.99	0.28	3.91	100	N/A
	1986	6	3.4 to 4.0	3.70	0.27	3.78	100	N/A
795 (Max.Turb.)	1985	7	3.6 to 4.1	3.90	0.18	3.97	100	N/A
	1986	6	3.3 to 4.9	3.83	0.58	3.76	100	N/A
791 (Max.Turb.)	1985	4	3.4 to 3.7	3.56	0.12	3.57	100	N/A
	1986	7	3.4 to 3.8	3.58	0.13	3.56	100	N/A

M.R.A. = Minimum Reportable Amount

TABLE 3.2.6 THUNDER BAY 1985/86 WATER QUALITY SUMMARY: TOTAL PHOSPHORUS

Results in ug/l P.W.Q.O.: 20 ug/l (guideline)

STATION		N	Range	Mean	S.D.	Median	%>MRA	%>PWQO
802 (Max.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	41 to 130	77.4	43.0	68.0	100	100
176 (Max.Turb.)	1985	4	32 to 63	49.0	15.0	51.5	100	100
	1986	8	27 to 55	36.0	11.8	30.5	100	100
176 (Min.Turb.)	1985	2	10 to 15	12.5	3.0	12.5	100	0
	1986	8	17 to 33	21.6	6.6	18.5	100	37
671 (Max.Turb.)	1985	4	37 to 53	45.0	7.0	45.5	100	100
	1986	8	30 to 72	44.6	14.1	44.0	100	100
671 (Min.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	17 to 30	22.5	4.4	21.0	100	63
677 (Max.Turb.)	1985	4	47 to 110	75.0	26.0	71.5	100	100
	1986	8	34 to 260	100.1	83.0	66.5	100	100
677 (Min.Turb.)	1985	2	8 to 54	31.0	32.0	31.0	100	50
	1986	8	7 to 60	21.0	17.8	14.5	100	25
663 (Max.Turb.)	1985	4	1 to 15	7.3	5.8	6.5	100	0
	1986	8	4 to 18	10.4	4.9	9.5	100	0
663 (Min.Turb.)	1985	4	3 to 14	8.3	5.1	8.0	100	0
	1986	8	7 to 19	11.0	4.3	10.0	100	0
668 (Max.Turb.)	1985	6	<1 to 13	N/A	N/A	8.0	83	0
	1986	8	3 to 6	4.8	1.3	5.0	100	0
668 (Min.Turb.)	1985	3	1 to 6	4.0	2.6	5.0	100	0
	1986	8	2 to 10	5.6	2.4	5.5	100	0
653 (Max.Turb.)	1985	7	<1 to 6	N/A	N/A	2.0	57	0
	1986	6	3 to 7	4.8	1.6	5.0	100	0
795 (Max.Turb.)	1985	7	<1 to 6	N/A	N/A	4.0	57	0
	1986	6	4 to 12	5.8	3.1	4.5	100	0
791 (Max.Turb.)	1985	4	<1 to 7	N/A	N/A	2.5	75	0
	1986	7	2 to 4	3.3	0.7	3.0	100	0

M.R.A. = Minimum Reportable Amount

TABLE 3.2.7 THUNDER BAY 1985/86 WATER QUALITY SUMMARY: TOTAL KJELDAHL NITROGEN

Results in ug/l P.W.Q.O.: N/A

STATION		N	Range	Mean	S.D.	Median	%>MRA	%>PWQO
802 (Max.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	470 to 970	641	200	560	100	N/A
176 (Max.Turb.)	1985	4	420 to 520	480	50	520	100	N/A
	1986	8	420 to 560	467	53	450	100	N/A
176 (Min.Turb.)	1985	2	170 to 220	195	30	195	100	N/A
	1986	8	220 to 370	271	49	260	100	N/A
671 (Max.Turb.)	1985	4	460 to 620	540	60	535	100	N/A
	1986	8	430 to 730	531	103	520	100	N/A
671 (Min.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	240 to 400	334	58	320	100	N/A
677 (Max.Turb.)	1985	4	520 to 1800	970	570	775	100	N/A
	1986	8	460 to 5500	1514	1743	715	100	N/A
677 (Min.Turb.)	1985	2	160 to 340	250	130	250	100	N/A
	1986	8	170 to 690	340	205	230	100	N/A
663 (Max.Turb.)	1985	4	130 to 310	210	80	200	100	N/A
	1986	8	160 to 350	249	75	230	100	N/A
663 (Min.Turb.)	1985	4	150 to 200	175	21	175	100	N/A
	1986	8	190 to 420	256	90	230	100	N/A
668 (Max.Turb.)	1985	6	140 to 200	170	20	165	100	N/A
	1986	8	170 to 200	180	13	170	100	N/A
668 (Min.Turb.)	1985	3	100 to 140	120	20	120	100	N/A
	1986	8	160 to 190	179	11	170	100	N/A
653 (Max.Turb.)	1985	7	150 to 160	154	5	150	100	N/A
	1986	6	160 to 290	195	48	180	100	N/A
795 (Max.Turb.)	1985	7	140 to 230	146	54	170	100	N/A
	1986	6	170 to 300	213	49	200	100	N/A
791 (Max.Turb.)	1985	4	130 to 160	143	15	140	100	N/A
	1986	7	140 to 420	193	101	160	100	N/A

M.R.A. = Minimum Reportable Amount

TABLE 3.2.8 THUNDER BAY 1985/86 WATER QUALITY SUMMARY: SUSPENDED SOLIDS

Results in mg/l P.W.Q.O.: N/A

STATION		N	Range	Mean	S.D.	Median	%>MRA	%>PWQO
802 (Max.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	6 to 45	17.9	15.7	11.5	100	N/A
176 (Max.Turb.)	1985	4	7 to 55	28.5	25.2	26.0	100	N/A
	1986	8	4 to 7	5.6	1.3	5.5	100	N/A
176 (Min.Turb.)	1985	2	5 to 5	5.0	0.0	5.0	100	N/A
	1986	8	4 to 25	10.3	9.3	5.5	100	N/A
671 (Max.Turb.)	1985	4	5 to 9	6.8	1.7	6.5	100	N/A
	1986	8	2 to 6	4.3	1.7	4.0	100	N/A
671 (Min.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	2 to 7	4.1	1.9	4.0	100	N/A
677 (Max.Turb.)	1985	4	8 to 8	8.0	0.0	8.0	100	N/A
	1986	8	3 to 9	6.4	2.3	7.0	100	N/A
677 (Min.Turb.)	1985	2	1 to 30	15.5	20.5	15.5	100	N/A
	1986	8	2 to 7	3.8	1.7	3.5	100	N/A
663 (Max.Turb.)	1985	4	1 to 3	1.8	1.0	1.0	100	N/A
	1986	8	1 to 3	1.9	0.8	2.0	100	N/A
663 (Min.Turb.)	1985	4	1 to 6	2.3	2.5	1.5	100	N/A
	1986	8	1 to 2	1.5	0.5	1.5	100	N/A
668 (Max.Turb.)	1985	6	1 to 7	2.0	2.4	1.0	100	N/A
	1986	8	1 to 1	1.0	0.0	1.0	100	N/A
668 (Min.Turb.)	1985	4	1 to 1	1.0	0.0	1.0	100	N/A
	1986	8	1 to 7	1.9	2.1	1.0	100	N/A
653 (Max.Turb.)	1985	7	1 to 1	1.0	0.0	1.0	100	N/A
	1986	6	1 to 1	1.0	0.0	1.0	100	N/A
795 (Max.Turb.)	1985	7	1 to 1	1.0	0.0	1.0	100	N/A
	1986	6	1 to 1	1.0	0.0	1.0	100	N/A
791 (Max.Turb.)	1985	4	1 to 1	1.0	0.0	1.0	100	N/A
	1986	7	1 to 1	1.0	0.0	1.0	100	N/A

M.R.A. = Minimum Reportable Amount

offshore stations, results varied too widely for any clear pattern to emerge. In both 1985 and 1986 the minimum suspended sediment concentrations observed at delta stations were less than 10 ug l^{-1} and were generally uniform throughout the water column. Maximum concentrations ranged up to 55 ug l^{-1} but were not always observed at the depth of maximum turbidity as measured with the transmissometer. The occasional discrepancy between field and laboratory measurements suggests that although collectively the correlation between laboratory turbidity and suspended sediment concentrations was good[1], field conditions were sufficiently variable to warrant repeat profiling prior to estimating the depths of maximum and minimum turbidity. This procedure should be adopted in future.

3.2.2 Trace Metals in Water

Copper, iron, and zinc were the only metals detected at concentrations greater than their respective PWQO. Copper was detected at 6 ug l^{-1} (above the PWQO of 5 ug l^{-1}) in one sample at the Mission River maximum turbidity station during 1985. Iron routinely exceeded the PWQO of 300 ug l^{-1} in both 1985 and 1986 at maximum turbidity stations throughout the delta area, but not at intermediate or offshore stations. Zinc was detected above the PWQO of 30 ug l^{-1} at the McKellar River maximum turbidity station in one sample during 1985 (150 ug l^{-1}) and one sample in 1986 (31 ug l^{-1}). One zinc sample greater than the PWQO was also detected in the maximum turbidity sample 4 km offshore from the McKellar River during 1985 (39 ug l^{-1}).

Unlike nutrients and certain physical parameters, there was no tendency for maximum median concentrations of any metals to be observed at the mouth of the Kaministiquia River: concentrations were generally similar throughout the delta. With the exception

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[1] $r = 0.81$ ($n = 64$) for maximum turbidity samples, and $r = 0.92$ ($n = 34$) for minimum turbidity samples

TABLE 3.2.9 THUNDER BAY 1985/86 WATER QUALITY SUMMARY: CHROMIUM

Results in ug/l P.W.Q.O.: 100 ug/l

STATION		N	Range	Mean	S.D.	Median	%>MRA	%>PWQO
802 (Max.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	9 to 21	13	4	11	100	0
176 (Max.Turb.)	1985	6	7 to 10	9	1	9	100	0
	1986	8	5 to 22	13	8	11	100	0
176 (Min.Turb.)	1985	44	<1 to 1	N/A	N/A	1	100	0
	1986	8	4 to 5	2	1	2	100	0
671 (Max.Turb.)	1985	6	5 to 17	8	4	7	100	0
	1986	7	6 to 14	9	3	8	100	0
671 (Min.Turb.)	1985	-	—	—	—	—	100	0
	1986	8	<1 to 4	N/A	N/A	2	75	0
677 (Max.Turb.)	1985	6	3 to 8	6	2	5	100	0
	1986	8	2 to 8	5	2	5	100	0
677 (Min.Turb.)	1985	3	2 to 3	2	1	2	100	0
	1986	8	2 to 8	5	2	5	100	0
663 (Max.Turb.)	1985	7	<1 to 3	N/A	N/A	<1	14	0
	1986	8	1 to 3	1	1	1	100	0
663 (Min.Turb.)	1985	6	<1 to 2	N/A	N/A	<1	33	0
	1986	7	<1 to 1	N/A	N/A	1	57	0
668 (Max.Turb.)	1985	8	<1 to 4	N/A	N/A	1	63	0
	1986	8	<1 to 1	N/A	N/A	1	63	0
668 (Min.Turb.)	1985	6	<1 to <1	N/A	N/A	<1	0	0
	1986	8	<1 to 1	N/A	N/A	1	63	0
653 (Max.Turb.)	1985	8	<1 to 2	N/A	N/A	1	50	0
	1986	6	<1 to 1	N/A	N/A	1	50	0
795 (Max.Turb.)	1985	6	<1 to 1	N/A	N/A	<1	33	0
	1986	6	<1 to 1	N/A	N/A	<1	33	0
791 (Max.Turb.)	1985	4	<1 to 1	N/A	N/A	<1	33	0
	1986	7	<1 to 1	N/A	N/A	<1	33	0

M.R.A. = Minimum Reportable Amount

TABLE 3.2.10 THUNDER BAY 1985/86 WATER QUALITY SUMMARY: COPPER

Results in ug/l P.W.Q.O.: 5 ug/l

STATION		N	Range	Mean	S.D.	Median	%>MRA	%>PWQO
802 (Max.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	2 to 5	3	1	3	100	0
176 (Max.Turb.)	1985	6	<1 to 6	N/A	N/A	3	67	17
	1986	8	2 to 3	2	1	2	100	0
176 (Min.Turb.)	1985	4	<1 to 1	N/A	N/A	1	50	0
	1986	8	1 to 2	1	1	2	100	0
671 (Max.Turb.)	1985	6	1 to 4	3	1	3	100	0
	1986	8	1 to 2	2	1	2	100	0
671 (Min.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	1 to 2	1	1	1	100	0
677 (Max.Turb.)	1985	6	1 to 5	2	1	3	100	0
	1986	8	2 to 5	3	1	2	100	0
677 (Min.Turb.)	1985	3	2 to 3	2	1	2	100	0
	1986	7	<1 to 2	N/A	N/A	1	86	0
663 (Max.Turb.)	1985	7	<1 to 3	N/A	N/A	2	43	0
	1986	8	1 to 2	1	1	1	100	0
663 (Min.Turb.)	1985	6	<1 to 3	N/A	N/A	2	50	0
	1986	7	1 to 2	1	4	1	100	0
668 (Max.Turb.)	1985	8	<1 to 4	N/A	N/A	1	88	0
	1986	8	<1 to 1	N/A	N/A	1	88	0
668 (Min.Turb.)	1985	4	<1 to 4	N/A	N/A	4	50	0
	1986	8	<1 to 2	N/A	N/A	1	62	0
653 (Max.Turb.)	1985	8	<1 to 2	N/A	N/A	1	50	0
	1986	8	1 to 1	1	0	1	100	0
795 (Max.Turb.)	1985	8	<1 to 4	N/A	N/A	1	63	0
	1986	6	<1 to 2	N/A	N/A	1	83	0
791 (Max.Turb.)	1985	4	1 to 4	2	2	1	100	0
	1986	7	<1 to 1	N/A	N/A	1	71	0

M.R.A. = Minimum Reportable Amount

TABLE 3.2.11 THUNDER BAY 1985/86 WATER QUALITY SUMMARY: IRON

Results in ug/l P.W.Q.O.: 300 ug/l

STATION		N	Range	Mean	S.D.	Median	%>MRA	%>PWQO
802 (Max.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	480 to 2300	1059	110	825	100	100
176 (Max.Turb.)	1985	6	510 to 2600	1040	860	540	100	100
	1986	8	350 to 520	44	73	485	100	100
176 (Min.Turb.)	1985	4	100 to 200	145	40	140	100	0
	1986	8	170 to 1000	441	353	300	100	50
671 (Max.Turb.)	1985	6	370 to 640	520	90	540	100	100
	1986	8	240 to 530	374	107	350	100	62
671 (Min.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	110 to 2100	563	653	370	100	50
677 (Max.Turb.)	1985	6	370 to 1100	650	250	620	100	100
	1986	8	440 to 2000	835	632	515	100	100
677 (Min.Turb.)	1985	3	70 to 930	610	470	830	100	67
	1986	7	66 to 380	178	107	160	100	14
663 (Max.Turb.)	1985	7	25 to 280	114	127	30	100	0
	1986	8	23 to 260	108	97	81	100	0
663 (Min.Turb.)	1985	4	53 to 100	75	19	73	100	0
	1986	7	35 to 120	80	36	91	100	0
668 (Max.Turb.)	1985	8	17 to 93	60	30	65	100	0
	1986	8	14 to 240	63	76	35	100	0
668 (Min.Turb.)	1985	4	20 to 160	60	50	42	100	0
	1986	8	16 to 130	51	38	43	100	0
653 (Max.Turb.)	1985	8	27 to 67	45	10	41	100	0
	1986	6	12 to 30	22	8	26	100	0
795 (Max.Turb.)	1985	8	32 to 52	40	8	37	100	0
	1986	6	14 to 44	25	13	20	100	0
791 (Max.Turb.)	1985	4	12 to 25	20	6	17	100	0
	1986	7	11 to 23	14	4	12	100	0

M.R.A. = Minimum Reportable Amount

TABLE 3.2.12 THUNDER BAY 1985/86 WATER QUALITY SUMMARY: ZINC

Results in ug/l P.W.Q.O.: 30 ug/l

STATION		N	Range	Mean	S.D.	Median	%>MRA	%>PWQO
802 (Max.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	6 to 21	10	5	10	100	0
176 (Max.Turb.)	1985	6	<1 to 21	N/A	N/A	7	67	0
	1986	8	5 to 12	8	3	7	100	0
176 (Min.Turb.)	1985	4	<1 to 5	N/A	N/A	2	50	0
	1986	8	1 to 6	4	2	4	100	0
671 (Max.Turb.)	1985	6	2 to 150	28	6	5	100	17
	1986	8	3 to 31	9	10	4	100	12
671 (Min.Turb.)	1985	-	—	—	—	—	—	—
	1986	8	1 to 18	5	6	3	100	0
677 (Max.Turb.)	1985	6	2 to 9	5	3	6	100	0
	1986	8	<1 to 19	N/A	N/A	4	75	0
677 (Min.Turb.)	1985	3	2 to 5	4	1	4	100	0
	1986	7	<1 to 6	N/A	N/A	1	71	0
663 (Max.Turb.)	1985	7	<1 to 8	N/A	N/A	1	57	0
	1986	8	1 to 3	2	1	1	100	0
663 (Min.Turb.)	1985	6	<1 to 4	N/A	N/A	2	67	0
	1986	7	<1 to 2	N/A	N/A	2	71	0
668 (Max.Turb.)	1985	8	<1 to 39	N/A	N/A	2	88	13
	1986	8	<1 to 20	N/A	N/A	1	75	0
668 (Min.Turb.)	1985	6	<1 to 5	N/A	N/A	2	67	0
	1986	8	<1 to 20	N/A	N/A	1	62	0
653 (Max.Turb.)	1985	8	<1 to 5	N/A	N/A	3	75	0
	1986	6	<1 to 6	N/A	N/A	1	83	0
795 (Max.Turb.)	1985	6	<1 to 3	N/A	N/A	2	66	0
	1986	6	<1 to 7	N/A	N/A	2	83	0
791 (Max.Turb.)	1985	4	<1 to 15	N/A	N/A	3	75	0
	1986	7	1 to 22	7	9	1	100	0

M.R.A. = Minimum Reportable Amount

of chromium and iron, metals concentrations at minimum turbidity stations in the delta were generally similar to offshore conditions.

3.2.3 Resin, Fatty, and Aromatic Acids (RFAs) in Water

Of the 20 RFAs tested for, 14 were detected at least once at one or more stations. There was a general tendency for abietic acid and dehydroabietic acid, and oleic acid to be detectable at concentrations of from 5 ug l^{-1} to 20 ug l^{-1} in up to half the samples collected in the delta area. With the exception of results from August 16, 1985, none of the delta stations exhibited elevated concentrations of RFAs relative to each other. No RFAs were detectable at the intermediate zone stations 2 km to 4 km offshore from the delta or the station 6 km offshore from Whiskeyjack Pt. (Figure 1.1). Palmitic acid was, however, detected at a concentration of 10 ug l^{-1} on one occasion 3 km offshore from Grand Pt. and capric acid was detected at a concentration of 74 ug l^{-1} 6 km offshore from Bare Pt. (Figure 1.1). The presence of these compounds in offshore waters cannot, in this case, be directly attributed to flows from the Kaministiquia River despite the detection of these compounds at similar concentrations in the delta area, since they were not detected at the intermediate stations.

As mentioned, results from sampling on August 16, 1985 showed a distinctive pattern which was not observed on other days (Table 3.2.13). In this instance, the sample from the maximum turbidity station at the mouth of the Mission River contained detectable concentrations of 12 RFAs compared with one or two at other river mouth stations. Seven of them were resin acids, yielding a total resin acid (TRA) concentration of 510 ug l^{-1}. Of particular note were abietic acid with a concentration of 200 ug l^{-1}, and dehydroabietic acid (DHA) with a concentration of 170 ug l^{-1}. Although PWQOs do not yet exist for all RFAs, an objective has

TABLE 3.2.13 THUNDER BAY WATER QUALITY 1985/86: RESIN, FATTY AND AROMATIC ACIDS (ug/l)

STATION	COMPOUNDS DETECTED	11/06/85	14/06/85	15/08/85	16/08/85	31/05/86	02/06/86	12/08/86	15/08/86
802 (Max.Turb.)	Oleic Acid	---	---	---	---	ND/ND	ND/ND	ND/ND	ND/12
	Abietic Acid	---	---	---	---	ND/ND	10/ND	ND/ND	ND/ND
	Dehydroabietic Acid	---	---	---	---	ND/10	10/ND	ND/ND	ND/ND
176 (Max.Turb)	Myristic Acid	---	---	ND	10	ND/ND	ND/ND	ND/ND	ND/ND
	Stearic Acid	---	---	ND	10	ND/ND	ND/ND	ND/ND	ND/ND
	Benzoic Acid	---	---	ND	10	ND/ND	ND/ND	ND/ND	ND/ND
	Pimaric Acid	---	---	ND	20	ND/ND	ND/ND	ND/ND	ND/ND
	Sandaracopimaric Acid	---	---	ND	20	ND/ND	ND/ND	ND/ND	ND/ND
	Levopimaric Acid	---	---	ND	30	ND/ND	ND/ND	ND/ND	ND/ND
	Isopimaric Acid	---	---	ND	30	ND/ND	ND/ND	ND/ND	ND/ND
	Neoabietic Acid	---	---	ND	40	ND/ND	ND/ND	ND/ND	ND/ND
	Abietic Acid	---	---	ND	200	ND/ND	ND/ND	ND/ND	ND/11
	Dehydroabietic Acid	---	---	ND	170	ND/ND	ND/ND	ND/ND	ND/21
	Palmitic Acid	---	---	ND	20	ND/ND	ND/ND	ND/ND	ND/ND
	Oleic Acid	---	---	ND	ND	ND/ND	ND/ND	ND/ND	10/17
671 (Max.Turb.)	Abietic Acid	---	---	ND	ND	ND/ND*	ND/5	ND/ND	ND/ND
	Dehydroabietic Acid	---	---	10	10	ND/ND*	ND/5	ND/ND	14/13
671 (Min.Turb.)	Abietic Acid	---	---	---	---	ND/ND*	5/5	ND/ND	ND/ND
	Dehydroabietic Acid	---	---	---	---	ND/ND*	5/5	ND/ND	ND/ND
677 (Max.Turb.)	Myristic Acid	---	---	10	ND	ND/ND*	ND/ND	ND/ND	ND/ND
	Abietic Acid	---	---	ND	ND	ND/ND*	10/10	ND/ND	ND/ND
	Dehydroabietic Acid	---	---	10	ND	10/ND*	10/10	ND/ND	ND/ND
	Oleic Acid	---	---	ND	ND	ND/ND*	ND/ND	ND/ND	ND/14
	Capric Acid	---	---	ND	ND	71/40*	ND/ND	ND/ND	ND/ND
677 (Min.Turb.)	Myristic Acid	---	---	10	ND	ND/ND*	ND/ND	ND/ND	ND/ND
	Isopimaric Acid	---	---	ND	ND	ND/ND*	ND/ND	ND/40	ND/ND
	Abietic Acid	---	---	ND	ND	ND/ND*	ND/ND	ND/94	ND/ND
	Dehydroabietic Acid	---	---	ND	ND	ND/ND*	ND/ND	ND/ND	ND/ND
	Oleic Acid	---	---	ND	ND	ND/ND*	ND/ND	ND/71	ND/ND
	Lauric Acid	---	---	ND	ND	76/ND*	ND/ND	ND/ND	ND/ND
653 (Max.Turb.)	Palmitic Acid	---	---	---	10	ND/ND	ND/ND	ND/ND	ND/ND
791 (Max.Turb.)	Capric Acid	---	---	ND	ND	ND/74*	ND/ND	ND/ND	ND/ND

"ND" = NOT DETECTED
"---" = NO RESULTS AVAILABLE
" * " = SAMPLED ON 30/05/86

been developed for DHA and a guideline has been developed for TRA (MOE 1988). These criteria are pH dependent with the DHA objective being 8 ug l^{-1} at pH 7.0 and 12 ug l^{-1} at pH 7.5. The TRA guideline is 25 ug l^{-1} at pH 7.0 and 45 ug l^{-1} at pH 7.5. The receiving water pH corresponding to this sample was 7.2 so by interpolation the appropriate DHA objective was 9.6 ug l^{-1}, and the TRA guideline was 33 ug l^{-1}. The detection of numerous RFAs at grossly elevated concentrations at the mouth of the Mission River but not at other river mouth stations, or upstream at the top of the delta, provides some evidence that the source was not from upstream but may have been connected to an accidental or irregular effluent discharge from the nearby Abitibi mill (although final effluent is not discharged to the river).

Although no other extreme situations were observed, there was a general tendency for concentrations of DHA to slightly exceed the objective in from 20% to 40% of samples at river mouth stations. Concentrations of TRA were also detected in excess of the guideline on one other occasion at the mouth of the Mission River (32 ug l^{-1} on August 15, 1986) and at the mouth of the Kaministiquia River on August 12, 1986 with a concentration of 134 ug l^{-1}. These instances of RFA concentrations in excess of PWQO/G, while infrequent, demonstrate direct water quality impairment in the lower Kaministiquia River and delta primarily attributable to pulp and paper mill effluent discharged 10 km upstream. This suggests that the dilution capacity of the river is not sufficient to consistently absorb the effluent loads currently discharged to it.

3.2.4 Trace Organics in Water

Of the 48 tests analyzed for in the organochlorine, chlorophenol, chlorobenzene, and phenoxy acid scans, 19 were detected on at least one occasion at one or more stations. Of these, alpha-BHC (the most soluble isomer of hexachlorocyclohexane) was the only

TABLE 3.2.14 THUNDER BAY WATER QUALITY 1985/86: ORGANOCHLORINES, CHLOROBENZENES, PHENOXY ACIDS AND CHLOROPHENOLS (ng/l)

STATION	COMPOUNDS DETECTED	11/06/85	14/06/85	15/08/85	16/08/85	31/05/86	02/06/86	12/08/86	15/08/86
802 (Max.Turb.)	a-BHC	---	---	---	---	2/ 5	ND/ 3	2/ 4	2
	g-BHC	---	---	---	---	ND/ ND	ND/ ND	ND/ 1	ND
	Heptachlor	---	---	---	---	ND/ ND	4/ 10	ND/ ND	ND
	endosulphan sulphate	---	---	---	---	ND/ 7	ND/ ND	ND/ ND	ND
	Pentachlorobenzene	---	---	---	---	6/ 10	5/ 11	ND/ ND	ND
	Hexachloroethane	---	---	---	---	ND/ 6	ND/ ND	ND/ ND	ND
	2,4,6-Trichlorophenol	---	---	---	---	640/590	957/ ND	80/100	450/230
	2,4,D-Propionic Acid	---	---	---	---	ND/ ND	ND/ ND	ND/ ND	230/140
176 (Max.Turb.)	a-BHC	---	---	4	3	4/ 3	3/ 4	3/ 4	3/ 3
	b-BHC	---	---	ND	3	ND/ ND	ND/ ND	ND/ ND	ND/ ND
	HCB	---	---	ND	2	ND/ ND	ND/ ND	ND/ ND	ND/ ND
	endosulphan sulphate	---	---	ND	ND	14/ 7	ND/ ND	ND/ ND	ND/ ND
	Heptachlor	---	---	ND	ND	ND/ ND	7/ 7	ND/ ND	ND/ ND
	Heptachlor epoxide	---	---	ND	ND	1/ ND	ND/ ND	ND/ ND	ND/ ND
	1,2,3,4-Tetrachlorobenzene	---	---	ND	4	ND/ ND	ND/ ND	ND/ ND	ND/ ND
	1,2,4,5-Tetrachlorobenzene	---	---	ND	7	ND/ ND	ND/ ND	ND/ ND	ND/ ND
	Pentachlorobenzene	---	---	6	8	11/ 9	9/ 10	ND/ ND	ND/ ND
	2,6,a-Trichlorotoluene	---	---	ND	ND	5/ ND	ND/ ND	ND/ ND	ND/ ND
	2,4,6-Trichlorophenol	---	---	ND	ND	540/460	189/ ND	60/220	390/320
	Pentachlorophenol	---	---	243	69	ND/ ND	ND/ ND	ND/ ND	ND/ ND
	2,4,D-Propionic Acid	---	---	ND	ND	ND/ ND	ND/ ND	290/ ND	320/250
176 (Min.Turb.)	a-BHC	---	---	6	3	6/ 7	5/ 5	2/ 6	4/ 4
	g-BHC	---	---	ND	ND	2/ 2	8/ ND	ND/ 1	ND/ ND
	p,p-DDE	---	---	16	ND	ND/ ND	ND/ ND	ND/ ND	ND/ ND
	Heptachlor	---	---	ND	ND	ND/ ND	7/ 3	ND/ ND	ND/ ND
	PCBs	---	---	ND	ND	ND/ ND	ND/ ND	80/ ND	ND/ ND
	Pentachlorobenzene	---	---	ND	2	2/ 1	ND/ ND	ND/ ND	ND/ ND
	2,4,5-Trichlorotoluene	---	---	ND	ND	83/ ND	ND/ ND	ND/ ND	ND/ ND
	2,4,6-Trichlorophenol	---	---	ND	ND	60/ 50	ND/ ND	210/ ND	ND/ ND
671 (Max.Turb.)	a-BHC	---	---	4	3	5/ 5*	2/ 4	4/ 3	4/ 4
	g-BHC	---	---	ND	ND	ND/ ND*	ND/ ND	1/ ND	ND/ ND
	Heptachlor	---	---	ND	ND	7/ 11*	2/ 9	ND/ ND	ND/ ND
	Endosulphan II	---	---	ND	ND	7/ 6*	ND/ ND	ND/ ND	ND/ ND
	Endosulphan sulphate	---	---	ND	ND	ND/ 9*	ND/ ND	ND/ ND	ND/ ND
	1,2,4-Trichlorobenzene	---	---	9	ND	ND/ ND*	ND/ ND	ND/ ND	ND/ ND
	1,2,4,5-Tetrachlorobenzene	---	---	5	ND	ND/ ND*	ND/ ND	ND/ ND	ND/ ND
	Pentachlorobenzene	---	---	6	3	2/ 6*	ND/ 4	ND/ ND	ND/ ND
	2,4,6-Trichlorophenol	---	---	ND	ND	130/170*	310/ 63	---/110	310/330

"ND" = NOT DETECTED
"---" = NO RESULTS AVAILABLE
" * " = SAMPLED ON 30/05/86

TABLE 3.2.14 CONTINUED

STATION	COMPOUNDS DETECTED	11/06/85	14/06/85	15/08/85	16/08/85	31/05/86	02/06/86	12/08/86	15/08/86
671 (Min.Turb.)	a-BHC	---	---	---	---	6/ 6*	ND/ 5	3/ 3	4/ 2
	g-BHC	---	---	---	---	ND/ ND*	1/ 1	ND/ ND	ND/ ND
	Heptachlor	---	---	---	---	8/ 7*	4/ 3	ND/ ND	ND/ ND
	Endosulphan sulphate	---	---	---	---	5/ 5*	ND/ ND	ND/ ND	ND/ ND
	2,4,6-Trichlorophenol	---	---	---	---	ND/ ND*	ND/ 69	ND/ 50	ND/ ND
677 (Max.Turb.)	a-BHC	---	---	4	4	3/ 3*	ND/ 3	3/ 3	3
	g-BHC	---	---	ND	ND	ND/ND*	ND/ ND	ND/ ND	2
	Heptachlor	---	---	ND	ND	ND/ 6*	3/ ND	ND/ ND	ND
	1,2,4-Trichlorobenzene	---	---	15	ND	ND/ND*	ND/ ND	ND/ ND	ND
	1,2,4,5-Tetrachlorobenzene	---	---	5	ND	ND/ND*	ND/ ND	ND/ ND	ND
	Pentachlorobenzene	---	---	4	3	ND/ 5*	ND/ ND	ND/ ND	ND
	2,4,6-Trichlorophenol	---	---	ND	ND	461/490*	450/400	---	220/130
	Pentachlorophenol	---	---	ND	58	ND/ND*	ND/ ND	ND/ ND	ND/ ND
677 (Min.Turb.)	a-BHC	---	---	4	4	6/ 5*	6/ 4	4/ 3	3/ 3
	g-BHC	---	---	ND	ND	ND/ND*	ND/ ND	1/ ND	ND/ ND
	Heptachlor	---	---	ND	ND	3/ND*	2/ ND	ND/ ND	ND/ ND
	Pentachlorobenzene	---	---	ND	2	ND/ 6*	ND/ ND	ND/ ND	ND/ ND
	Pentachlorophenol	---	---	ND	86	ND/ND*	ND/ ND	ND/ ND	ND/ ND
663 (Max.Turb.)	a-BHC	---	---	5	4	7/ 7	4/ 6	4/ 4	2/ 2
	g-BHC	---	---	ND	ND	1/ 2	ND/ ND	ND/ ND	ND/ ND
	Heptachlor	---	---	ND	ND	ND/ ND	5/ 8	ND/ ND	ND/ ND
	Pentachlorobenzene	---	---	ND	ND	ND/ ND	3/ ND	ND/ ND	ND/ ND
	2,4,6-Trichlorophenol	---	---	ND	ND	ND/ ND	265/283	ND/ ND	ND/ ND
	2,4,D-Propionic Acid	---	---	ND	ND	ND/ ND	136/442	ND/ ND	ND/ ND
663 (Min.Turb.)	a-BHC	---	---	6	2	7/ 7	5/ 4	4/ 4	3/ 5
	g-BHC	---	---	ND	ND	1/ 2	ND/ ND	ND/ ND	ND/ ND
	Heptachlor	---	---	ND	ND	ND/ ND	5/ 5	ND/ ND	ND/ ND
	Pentachlorobenzene	---	---	2	3	ND/ ND	ND/ ND	ND/ ND	ND/ ND
	Pentachlorophenol	---	---	ND	130	ND/ ND	ND/ ND	ND/ ND	ND/ ND
668 (Max.Turb.)	a-BHC	---	---	5/ 4	4/ 5	7/ 5	5/ 4	4/ 4	4/ 5
	g-BHC	---	---	ND/ ND	ND/ ND	2/ ND	ND/ ND	ND/ ND	ND/ ND
	Heptachlor	---	---	ND/ ND	ND/ ND	4/ ND	6/ 4	ND/ ND	ND/ ND
	Pentachlorobenzene	---	---	ND/ ND	1/ ND	ND/ ND	ND/ ND	ND/ ND	ND/ ND
668 (Min.Turb.)	a-BHC	---	---	4	---	5/ 5	7/ ND	4/ 3	4/ 3
	g-BHC	---	---	ND	---	ND/ 1	2/ ND	ND/ ND	ND/ ND
	Heptachlor	---	---	ND	---	2/ 8	4/ ND	ND/ ND	ND/ ND
	p,p-DDE	---	---	19	---	ND/ ND	ND/ ND	ND/ ND	ND/ ND

'ND' = NOT DETECTED
'---' = NO RESULTS AVAILABLE
' * ' = SAMPLED ON 30/05/86

TABLE 3.2.14 CONTINUED

STATION	COMPOUNDS DETECTED	11/06/85	14/06/85	15/08/85	16/08/85	31/05/86	02/06/86	12/08/86	15/08/86
653 (Max.Turb.)	a-BHC	---	---	---	ND	---	4/ 5	5/ ND	4/ 7
	Heptachlor	---	---	---	ND	---	4/ 4	ND/ ND	ND/ ND
	Hexachloroethane	---	---	---	ND	---	6/ 6	ND/ ND	ND/ ND
795 (Max.Turb.)	a-BHC	---	---	---	2	---	7/ 5	5/ 5	5/ 5
	g-BHC	---	---	---	ND	---	2/ ND	ND/ ND	ND/ ND
	Heptachlor	---	---	---	ND	---	ND/ 3	ND/ ND	ND/ ND
791 (Max.Turb.)	a-BHC	---	---	4	7	ND/ 7*	6	4/ 4	4/ 7
	b-BHC	---	---	2	ND	ND/ND*	ND	ND/ ND	ND/ ND
	g-BHC	---	---	2	ND	ND/ND*	1	ND/ ND	ND/ 1
	Heptachlor	---	---	ND	ND	ND/ND*	8	ND/ ND	ND/ ND

'ND' = NOT DETECTED
'---' = NO RESULTS AVAILABLE
' * ' = SAMPLED ON 30/05/86

compound detected routinely being found in 97% of all samples at concentrations of up to 7 ng l^{-1}. This compound exhibited no concentration gradients, has no PWQO, and has been routinely detected at similar low concentrations throughout the Great Lakes basin. Other compounds detected occasionally at virtually all stations were lindane (gamma-BHC) at concentrations of 1 or 2 ng l^{-1}, and heptachlor at concentrations of up to 11 ng l^{-1}. As with alpha-BHC, there were no concentration gradients identifying the Kaministiquia River as a source of either compound.

Of the compounds directly related to pulp and paper mill effluent, 2,4,6-trichlorophenol was the most prevalent being detected in 17% of all samples, and at all river mouth stations. The highest concentration detected was 957 ng l^{-1} at the top of the delta with lower concentrations at the river mouths, and no detectable concentrations in the offshore samples. This concentration gradient clearly identifies the Kaministiquia River as the source.

No chlorophenols, chlorobenzenes, or phenoxy acids were detected at concentrations in excess of the PWQO. Three organochlorine compounds were, however, occasionally detected above their respective PWQO. Endosulphan was detected at concentrations of 6 ng l^{-1} and 7 ng l^{-1} at the mouth of the McKellar River (the PWQO is 3 ng l^{-1}). The DDT metabolite p,p-DDE was detected once at the mouth of the Mission River at a concentration of 16 ng l^{-1}, and once 4 km offshore from the Mission River at a concentration of 19 ng l^{-1} (the PWQO for DDT and metabolites is 3 ng l^{-1}). The third was heptachlor which was detected at virtually all stations in from 10% to 50% of samples at concentrations of up to 11 ng l^{-1}. The minimum reportable amount and the PWQO are both 1 ng l^{-1}.

3.2.5 Water Quality Variability

Two aspects of water quality variability were examined. First, a comparison was made between samples collected from the depths of maximum and minimum turbidity at individual stations, and second, a comparison was made between stations and between seasons. The first comparison used the Wilcoxon signed rank test on paired observations at all stations with two sampling depths. The second employed a 2-way analysis of variance (ANOVA) for all suitable parameters and sampling stations. Only those stations and parameters having all results greater than the minimum reportable amount were compared.

For 1985 results there was a significant difference ($p < 0.05$) between maximum and minimum turbidity samples for sodium, DOC, TKN, sulphate, COND25, and BOD5. In 1986, significant differences ($p < 0.05$) existed for TP, chromium, iron, manganese, and zinc in addition to these parameters.

The 2-way ANOVA compared mean concentrations of contaminants between stations and between surveys. Since replicate samples were obtained at each station within each survey (two in 1985, and four in 1986) it was possible to test for interaction between station and survey effects. In 1985 suitable results were not consistently available, but in 1986 it was possible to compare a standard group of six stations (the four delta stations plus the two nearshore stations) for physical parameters, nutrients, and metals. These results are summarized in Table 3.2.15.

With the exception of chromium, all parameters displayed significant differences between station means for maximum turbidity samples. However, significant differences were also present between survey means for most parameters (BOD5, TP, TKN, sulphate, COND25, alkalinity, ammonia, sodium, DOC), and several (TP, TKN, COND25, alkalinity, ammonia, sodium, and DOC) exhibited

TABLE 3.2.15: SUMMARY OF 2-WAY ANOVA FOR 1986 WATER QUALITY DATA

PARAMETER	SIGNIFICANT* DIFFERENCE STATIONS	SIGNIFICANT DIFFERENCE SURVEYS	SIGNIFICANT INTERACTION
Suspended Solids	Yes	No	No
Turbidity	Yes	No	No
BOD	Yes +	Yes	No
Total P	Yes	Yes +	Yes
TKN	Yes	Yes	Yes
Sulphate	Yes +	Yes	No
Conductivity	Yes	Yes +	Yes
Alkalinity	Yes	Yes +	Yes
Ammonia	Yes	Yes +	Yes
Sodium	Yes +	Yes	Yes
DOC	Yes +	Yes	Yes
Iron	Yes	No	No
Manganese	Yes	No	No
Aluminum	Yes	No	No
Chromium	No	No	No
Copper	Yes +	Yes	No
Zinc	Yes	Yes +	No

Comparisons between stations 802, 176, 671, 677, 663, and 668 for all parameters except ammonia which does not include 663.

* Significant at $p < 0.05$

+ Predominant main effect

significant interaction between station and survey effects. This interaction indicates that relative differences between stations were not consistent from one survey to the next.

Differences between station means were clearly the result of the steep water quality gradient between the delta stations and those in the nearshore area. Differences among survey means resulted from the tendency for summer survey means to exceed those found in the late spring for all parameters other than DOC. This tendency resulted chiefly from differences at the delta stations: concentrations at the stations 2 km and 4 km offshore remained relatively constant (see Appendix B). Several factors, including variability in the quantity and quality of effluent discharges to the Kaministiquia River, were likely to have contributed to this seasonal pattern, although reduced summer flow in the river suggests itself as the most obvious cause. In 1986 flow into the lower Kaministiquia River (as determined by Ontario Hydro at the Kakabeka Falls powerhouse) went from approximately 41.1 m^3s^{-1} during the period May 31 to June 2, to 18.2 m^3s^{-1} during the period August 12 to 15.

The tendency for interaction between station and survey effects demonstrates the need for caution when interpreting water quality data obtained from relatively few samples. In essence, this points out that it is not possible to characterize relative differences among stations on the basis of a single survey, nor is it meaningful to typify seasonal variation in the area based on data from one station.

Specific, separate sampling strategies will be required in future to obtain useful data for temporal trend analysis, and to identify spatial water quality zones. In general, however, future water quality surveys should stratify sampling to ensure the greatest spatial coverage in the delta and nearshore area

with samples taken at more than one depth. For trend analysis frequent (e.g. weekly) samples should be obtained in the lower river and delta area, with less frequent sampling (e.g. monthly) offshore (e.g. 4 km from the delta).

3.3 Sediment Quality Sampling

Appendix C lists the 40 tests carried out on sediment samples. Results for metals and nutrients are shown in Table 3.3.1 while data for those organochlorine compounds detected in one or more samples at one or more stations are presented in Table 3.3.2 . Grain size results have been summarized (Table 3.3.3) to show the range of particle diameters for each sample, as well as median grain size (in um), percentage less than 63 um (silt and clay), percentage less than 16 um, and percentage less than 4 um (clay). Table 3.3.4 summarizes the Wentworth particle size scale for reference.

There are currently no sediment criteria equivalent to the PWQO/G for evaluating bulk sediment chemistry data, although guidelines for nutrients and physical parameters (solvent extractables, % loss on ignition, TOC, TP, TKN), trace metals, PCBs, and organochlorine pesticides are under development. Until these become available the only related criteria are the Provincial dredging guidelines for assessing the suitability of dredged material for open water disposal (MOE 1976). These are listed in Table 3.3.5 for general reference although in the absence of corresponding biological data (such as benthic enumeration, sediment bioassays) they do not provide the basis for adequate assessment of sediment contamination.

In addition to the complete data listing provided in Table 3.3.1, median results for metals, nutrients, and physical parameters have been summarized in Table 3.3.6 . This Table also contains

TABLE 3.3.1: THUNDER BAY SEDIMENT METALS, NUTRIENTS AND PHYSICAL PARAMETERS 1985 AND 1986

STATION	DATE YYMMDD	TIME	SAMPLE NUMBER	ALUMINUM UG/G	ARSENIC UG/G	CADMIUM UG/G	CHROMIUM UG/G	COPPER UG/G	MERCURY UG/G	NICKEL UG/G	LEAD UG/G	ZINC UG/G	MANGANESE UG/G	IRON UG/G	% LOI	TOC MG/G	TOTAL P MG/G	TOTAL N MG/G
176	850608	1055	10250	17000	---	2.60*	52*	53*	0.34*	27*	9.8	99	310	31000	---	17.0	0.60	0.6
	850608	1058	10251	18000	---	2.50*	53*	73*	0.33*	28*	12.0	110*	310	31000	---	18.0	0.70	0.6
	850814	932	37037	20000	---	< 0.20	65*	50*	0.28	34*	7.9	110*	350	35000	---	20.0	0.69	1.1
	850814	940	37038	20000	---	0.22	69*	49*	0.27	35*	9.5	110*	360	36000	---	25.0	0.78	1.2
	860604	933	16884	20000	7.13	0.94	73*	46*	0.18	32*	14.0	120*	390	37000	5.0	16.0	0.74	1.0
	860604	945	16885	20000	6.43	0.34	76*	46*	0.18	31*	12.0	120*	380	36000	3.6	18.0	0.55	0.7
	860817	825	16147	19000	6.60	0.24	78*	44*	0.19	31*	15.0	120*	350	35000	4.9	24.0	0.85	1.1
	860817	830	16148	19000	7.70	0.30	71*	43*	0.16	29*	15.0	120*	350	34000	4.1	21.0	0.79	1.0
663	850608	938	10246	24000	---	3.80*	76*	74*	0.31*	37*	18.0	150*	520	41000	---	21.0	0.90	1.2
	850608	0	10247	23000	---	3.40*	68*	81*	0.34*	36*	20.0	150*	460	40000	---	20.0	0.90	1.1
	850814	944	37039	20000	---	< 0.20	44*	48*	0.41*	33*	14.0	110*	290	33000	---	29.0	0.69	0.9
	850814	950	37040	24000	---	< 0.20	69*	62*	0.29	39*	16.0	140*	620	43000	---	29.0	1.05*	1.8
	860604	900	16881	22000	8.01*	1.00	85*	51*	0.24	32*	18.0	130*	410	37000	4.9	23.0	0.82	1.4
	860604	908	16882	27000	8.37*	1.30*	92*	64*	0.26	37*	19.0	150*	430	42000	5.1	26.0	0.81	1.3
	860817	810	16145	23000	7.90	0.29	84*	54*	0.28	33*	20.0	140*	420	39000	5.8	30.0	1.11*	1.5
	860817	815	16146	22000	8.50*	0.25	76*	50*	0.26	31*	19.0	130*	400	37000	5.7	27.0	0.96	1.4
668	850608	913	10244	26000	---	4.20*	65*	110*	0.66*	39*	33.0	170*	810	41000	---	22.0	0.90	1.3
	850608	915	10245	24000	---	3.70*	59*	76*	0.49*	35*	28.0	140*	810	39000	---	20.0	0.70	1.1
	850814	832	37035	20000	---	< 0.20	46*	42*	0.21	34*	13.0	92	620	40000	---	11.0	0.76	0.8
	850814	0	37036	20000	---	0.37	45*	46*	0.27	39*	17.0	92	440	32000	---	13.0	0.60	0.9
	860604	848	16879	20000	---	0.77	64*	51*	0.14	35*	19.0	100*	500	36000	2.0	7.8	0.60	0.7
	860604	900	16880	19000	10.20*	0.81	60*	48*	0.37*	30*	37.0	110*	480	34000	3.4	18.0	0.71	1.0
	860817	757	16143	19000	10.50*	0.10	61*	43*	0.26	30*	21.0	110*	680	37000	3.5	16.0	0.71	0.7
	860817	802	16144	22000	9.10*	0.40	60*	54*	0.42*	31*	25.0	120*	440	34000	3.9	17.0	0.83	1.0
677	850608	1030	10248	14000	---	2.30*	43*	35*	0.09	25	7.5	80	300	34000	---	11.0	0.70	0.6
	850814	958	37041	17000	---	< 0.20	59*	33*	0.11	35*	8.0	87	490	36000	---	20.0	0.69	1.0
	850814	959	37042	14000	---	< 0.20	39*	26*	0.08	27*	6.0	76	320	35000	---	14.0	0.63	0.7
	860604	1023	16888	16000	4.25	---	55*	31*	0.06	26*	11.0	78	340	33000	2.2	8.9	0.94	1.5
	860604	1035	16889	15000	4.57	---	54*	30*	0.07	26*	12.0	82	330	34000	2.3	10.0	0.41	0.5
	860817	907	16151	12000	4.00	0.97	52*	17	0.06	23	14.0	77	250	27000	1.2	---	0.60	0.4
	860817	912	16152	12000	4.20	2.30*	70*	19	0.07	34*	42.0	91	320	38000	1.3	13.0	0.64	0.4
671	860604	958	16886	18000	6.55	---	70*	39*	0.11	29*	12.0	110*	410	40000	4.3	23.0	0.90	1.7
	860604	1015	16887	19000	7.52	---	75*	45*	0.16	30*	12.0	120*	430	41000	4.6	24.0	0.94	1.4
	860817	848	16149	19000	8.10*	---	72*	43*	0.14	29*	14.0	120*	390	41000	5.3	26.0	0.90	1.2
	860817	848	16150	18000	7.90	---	67*	41*	0.14	28*	15.0	110*	370	38000	4.3	26.0	0.93	1.2

'*' denotes those concentrations exceeding Provincial Guidelines for open water disposal of dredged material.

TABLE 3.3.2: THUNDER BAY SEDIMENT ORGANOCHLORINES AND SOLVENT EXTRACTABLES 1985 AND 1986

STATION	DATE YYMMDD	TIME	SAMPLE NUMBER	TOTAL PCB	A-BHC	B-BHC	ALDRIN	DIELDRIN	DMDT	ENDRIN	ENDO SULFAN I	ENDO SULFAN II	ENDO SULFAN SULFATE	MIREX	HEPTA CHLOR EPOXIDE	OXYCHLOR DANE	OP-DDE	PP-DDD	PP-DDE	HCB	SOLEXT
				NG/G	NG/G	NG/G	NG/G	NG/G	NG/G	NG/G	NG/G	NG/G	NG/G	NG/G	NG/G	NG/G	NG/G	NG/G	NG/G	NG/G	UG/G
176	850608	1055	10250	ND	ND	ND	ND	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	850608	1058	10251	ND	ND	ND	ND	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	850814	932	37037	150*	ND	ND	3	ND	6	ND	ND	ND	ND	5	ND	ND	ND	ND	2	ND	---
	850814	940	37038	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	860604	933	16884	25	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	630
	860604	945	16885	45	ND	ND	ND	3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1200
	860817	825	16147	45	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	7	3	ND	ND	ND	ND	500
	860817	830	16148	25	ND	ND	ND	2	13	ND	ND	ND	8	ND	6	5	ND	ND	4	ND	530
663	850608	938	10246	ND	ND	ND	ND	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	---
	850608	0	10247	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5	---
	850814	944	37039	100*	ND	ND	2	3	ND	ND	ND	4	ND	ND	ND	ND	ND	ND	2	1	---
	850814	950	37040	185*	ND	ND	1	7	ND	13	ND	ND	ND	10	ND	ND	ND	ND	2	ND	---
	860604	900	16881	20	ND	ND	ND	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1080
	860604	908	16882	30	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1800
	860817	810	16145	20	ND	ND	ND	ND	ND	ND	ND	ND	5	ND	4	2	ND	ND	ND	ND	2000
	860817	815	16146	60*	ND	ND	ND	16	ND	ND	10	ND	26	ND	10	2	2	2	ND	ND	1300
668	850608	913	10244	65*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	850608	915	10245	25	ND	ND	ND	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	850814	832	37035	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	850814	0	37036	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	860604	848	16879	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	575
	860604	900	16880	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1300
	860817	757	16143	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	ND	420
	860817	802	16144	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	ND	850
677	850608	1030	10248	ND	ND	ND	ND	3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
	860604	1023	16888	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	380
	860604	1035	16889	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	530
	860817	907	16151	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4	ND	690
	860817	912	16152	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	520
671	860604	958	16886	40	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1100
	860604	1015	16887	40	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	380
	860817	848	16149	20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4	8	ND	ND	ND	ND	890
	860817	848	16150	55*	1	6	ND	2	ND	ND	ND	ND	ND	ND	2	ND	ND	ND	2	ND	1600

'*' identifies concentrations exceeding Provincial Guidelines for open water disposal

'ND' = not detected

'---' = no result available

TABLE 3.3.3 : GRAIN SIZE DATA FOR THUNDER BAY SEDIMENTS 1985/86

STATION	DATE YYMMDD	TIME	SAMPLE NUMBER	MAX. (UM)	MIN. (UM)	MEDIAN (UM)	<63 UM	<16 UM	<4 UM
176	850608	1055	10250	> 1000	0.5	25	89 %	31 %	7 %
176	850608	1058	10251	> 1000	0.5	25	83 %	33 %	8 %
176	850814	932	37037	> 1000	0.5	17	74 %	42 %	12 %
176	850814	940	37038	> 1000	0.5	12	80 %	47 %	14 %
176	860604	933	16884	> 1000	0.5	17	67 %	43 %	12 %
176	860604	945	16885	> 1000	0.5	17	73 %	42 %	11 %
176	860817	825	16147	> 1000	0.5	17	78 %	47 %	13 %
176	860817	830	16148	> 1000	0.5	12	78 %	52 %	19 %
663	850608	938	10246	35	0.4	6	100 %	77 %	34 %
663	850608	0	10247	35	0.4	6	100 %	77 %	34 %
663	850814	944	37039	> 1000	0.5	12	79 %	50 %	15 %
663	850814	950	37040	> 1000	0.4	9	94 %	69 %	27 %
663	860604	900	16881	> 1000	0.5	12	90 %	61 %	19 %
663	860604	908	16882	> 1000	0.5	9	92 %	64 %	15 %
663	860817	810	16145	—	0.5	9	—	68 %	27 %
663	860817	815	16146	—	0.5	9	—	66 %	26 %
668	850608	913	10244	35	0.4	4	100 %	80 %	42 %
668	850608	915	10245	35	0.4	4	100 %	81 %	42 %
668	850814	832	37035	> 1000	0.4	17	62 %	44 %	21 %
668	850814	0	37036	> 1000	0.5	35	52 %	31 %	12 %
668	860604	848	16879	> 1000	0.5	25	62 %	38 %	13 %
668	860604	900	16880	> 1000	0.3	25	65 %	36 %	11 %
668	860817	757	16143	—	—	—	—	—	— %
668	860817	802	16144	> 1000	0.5	25	66 %	37 %	11 %
677	850608	1030	10248	> 1000	0.5	88	35 %	15 %	5 %
677	850608	1030	10248	> 1000	0.5	88	39 %	17 %	6 %
677	850814	958	37041	> 1000	0.5	35	63 %	32 %	12 %
677	850814	959	37042	> 1000	0.5	88	39 %	16 %	6 %
677	860604	1023	16888	> 1000	0.5	53	49 %	32 %	11 %
677	860604	1035	16889	> 1000	0.4	88	48 %	25 %	8 %
677	860817	907	16151	> 1000	0.5	88	25 %	14 %	4 %
677	860817	912	16152	> 1000	0.8	88	26 %	9 %	2 %
671	860604	958	16886	> 1000	0.8	35	65 %	31 %	10 %
671	860604	1015	16887	> 1000	0.5	35	62 %	31 %	10 %
671	860817	848	16149	> 1000	0.5	17	75 %	41 %	14 %
671	860817	848	16150	> 1000	0.5	9	84 %	52 %	17 %

"——" = no result available

TABLE 3.3.4: SEDIMENT PARTICLE SIZE SCALE (WENTWORTH)

CLASS NAME	SIZE RANGE (in um)
Very Coarse Sand	2,000 to 1,000
Coarse Sand	1,000 to 500
Medium Sand	500 to 250
Fine Sand	250 to 125
Very Fine Sand	125 to 62
Coarse Silt	62 to 31
Medium Silt	31 to 16
Fine Silt	16 to 8
Very Fine Silt	8 to 4
Coarse Clay	4 to 2
Medium Clay	2 to 1
Fine Clay	1 to 0.5
Very Fine Clay	0.5 to 0.24

TABLE 3.3.5: GUIDELINES FOR OPEN WATER DISPOSAL OF DREDGED MATERIAL

PARAMETER	DRY WEIGHT CONCENTRATION
Loss on Ignition (600°C)	6 %
Total Phosphorus	1 mg/g
Oil and Grease (solvent extractable)	1.5 mg/g
Total Kjeldahl Nitrogen	2 mg/g
Iron	10 mg/g
Chemical Oxygen Demand	50 mg/g
Cadmium	1 ug/g
Arsenic	8 ug/g
Chromium	25 ug/g
Copper	25 ug/g
Nickel	25 ug/g
Cobalt	50 ug/g
Lead	50 ug/g
Zinc	100 ug/g
Ammonia	100 ug/g
Total PCBs	50 ng/g
Cyanide	100 ng/g
Mercury	300 ng/g
Silver	500 ng/g

TABLE 3.3.6: SUMMARY OF MEDIAN SEDIMENT CHEMISTRY RESULTS
THUNDER BAY 1985/86

BULK CHEMISTRY RESULTS	STN 176	STN 663	STN 668	STN 677	STN 671
ALUMINUM (mg/g)	19.50	23.00	20.00	14.50	18.50
ARSENIC (ug/g)	6.87	8.19	10.20	4.22	7.71
CADMIUM (ug/g)	0.32	0.63	0.59	0.97	---
CHROMIUM (ug/g)	0.00	76.00	60.00	54.00	71.00
COPPER (ug/g)	7.50	59.00	49.50	30.00	42.00
MERCURY (ug/g)	0.23	0.29	0.32	0.08	0.14
NICKEL (ug/g)	31.00	34.50	34.50	27.00	29.00
LEAD (ug/g)	12.00	18.50	23.00	11.00	13.00
ZINC (ug/g)	115.00	140.00	110.00	80.00	115.00
MANGANESE (ug/g)	350.00	425.00	560.00	330.00	400.00
IRON (mg/g)	35.00	38.00	38.00	34.00	40.50
%LOI	4.50	5.40	3.50	1.75	4.45
TOC (mg/g)	22.00	26.50	16.50	12.00	25.00
TOTAL P (mg/g)	0.72	0.90	0.71	0.64	0.92
TKN (mg/g)	0.90	1.40	0.90	0.50	1.30

GRAIN SIZE CORRECTED RESULTS*	STN 176	STN 663	STN 668	STN 677	STN 671
ALUMINUM (mg/g)	24.68	25.42	32.26	35.90	26.51
ARSENIC (ug/g)	9.34	9.00	14.74	12.76	10.44
CADMIUM (ug/g)	0.47	2.41	1.25	5.90	---
CHROMIUM (ug/g)	90.00	75.00	87.00	112.00	102.00
COPPER (ug/g)	62.00	71.00	82.00	67.00	59.00
MERCURY (ug/g)	0.31	0.31	0.52	0.27	0.18
NICKEL (ug/g)	41.00	39.00	47.00	64.00	42.00
LEAD (ug/g)	15.50	19.00	32.70	22.40	18.60
ZINC (ug/g)	152.00	150.00	169.00	195.00	165.00
MANGANESE (ug/g)	450.00	464.00	810.00	778.00	576.00
IRON (mg/g)	46.09	41.44	52.31	87.18	58.10

* Metals data normalized for percentage < 63 um

median results for metals following normalization for percentage less than 63 um.

3.3.1 Physical Parameters, Nutrients, and Trace Metals in Sediment

In virtually all cases, maximum concentrations, and maximum median concentrations, of trace metals were found at the stations 2 km or 4 km offshore from the delta. The only exception was iron at the mouth of the McKellar River . Minimum concentrations, and minimum median concentrations, of these parameters were all found at the mouth of the Kaministiquia River with the exception of cadmium at the mouth of the Mission River.

Of the metals, only lead was never detected at concentrations greater than the dredging guideline, and iron, chromium, copper, nickel, and zinc exceeded their respective guidelines in virtually all samples. Concentrations of these trace metals are, however, consistent with those typically found in quaternary sediments of the northern Lake Superior basin (Mothersill and Fung 1972).

Particle size results followed a similar pattern to chemical parameters with the most fine-grained sediments occurring at the stations 2 km offshore from the delta (with median particle diameters ranging from 6 um to 12 um) and 4 km offshore from the delta (with median particle diameters ranging from 4 um to 35 um). The coarsest sediments were found at the mouth of the Kaministiquia River where median particle diameters ranged from 35 um to 88 um. The relationship between bulk sediment chemistry and particle size (particularly for metals) is well established (Forstner and Wittman 1983) and the observed similarity in pattern between grain size and chemistry data suggests that at least some of the variation between stations is attributable to grain size effects. Testing for linear correlations among

metals, nutrients, and grain size (Table 3.3.7) reveals significant ($p < 0.05$) correlations between the grain size indicators "% <63 um" and "% <16 um", and all metals other than lead. Aluminum, copper, and zinc exhibit particularly strong correlations ($r \geq 0.8$) and these are illustrated in Figures 3.3.1 to 3.3.3 . The influence of grain size composition on bulk sediment chemistry means that metals concentrations at any given station will reflect both its proximity to a source and the local depositional environment prior to sampling (as reflected by grain size characteristics). In order to diminish the relative differences in metals concentrations attributable to differences in depositional environment, the metals data listed in Table 3.3.1 were normalized for the sediment fraction less than 63 um by scaling bulk concentrations according to the expression:

$$\frac{100}{(\% < 63 \text{ um})}$$ [1]

Median concentrations were then determined for each station and included in Table 3.3.6 .

The picture that emerges following this procedure differs considerably from that based upon bulk sediment chemistry data. Distinct elevations in concentrations of most metals are now evident at the mouth of the Kaministiquia River and 4 km offshore from the delta relative to other river mouth stations and the location 2 km offshore. Since differences attributable to depositional environment have been diminished it is fair to conclude that these two stations are demonstrating the influence of proximity to a source. In the case of the Kaministiquia River station this may be the STP discharge, since upstream sources

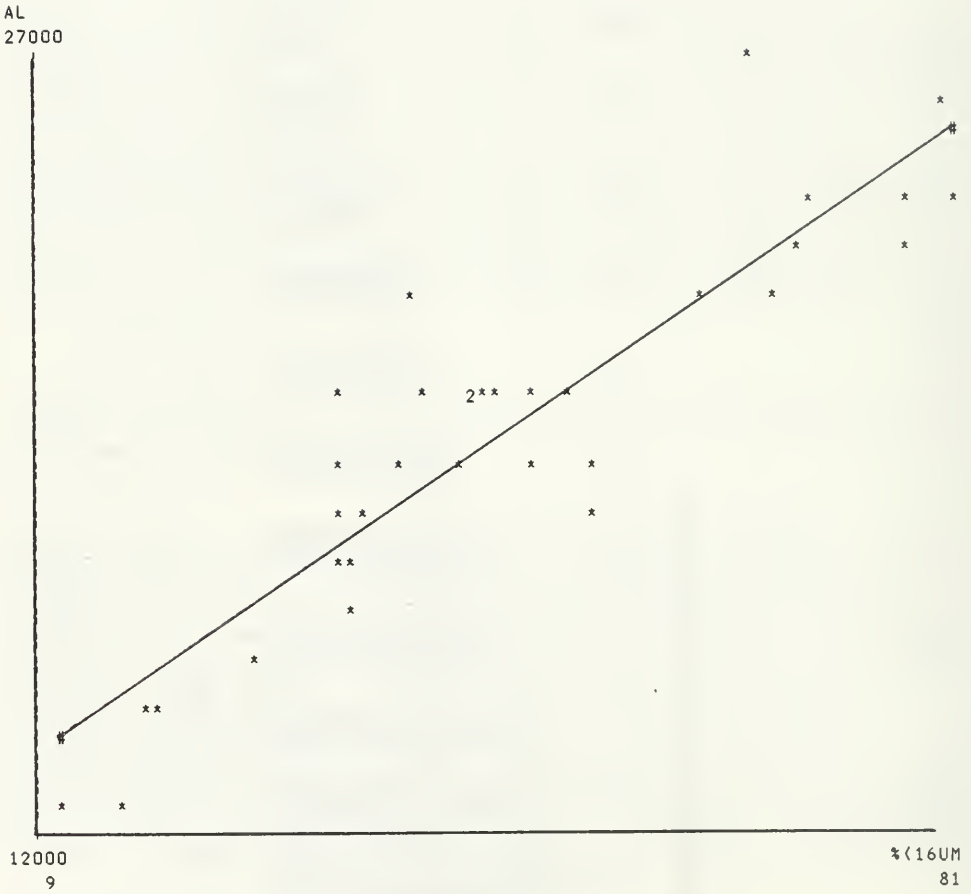
[1] In effect, this procedure assumes that all material coarser than 63 um is inert and that the bulk metals concentrations are solely attributable to the fraction less than 63 um.

TABLE 3.3.7: CORRELATIONS AMONG METALS, NUTRIENTS AND GRAIN SIZE

	AL	CR	CU	HG	NI	PB	ZN	MN	FE	TOC	TP	TKN	%<63UM	%<16UM
AL	1.00000													
CR	.47553	1.00000												
CU	.81187	.22084	1.00000											
HG	.70273	-.01229	.85219	1.00000										
NI	.70090	.28644	.54387	.50289	1.00000									
PB	.23940	.21430	.31280	.44424	.37580	1.00000								
ZN	.87960	.63528	.83982	.67380	.57618	.38425	1.00000							
MN	.65255	.09055	.64760	.59283	.62705	.44602	.56477	1.00000						
FE	.52397	.55901	.33815	.09090	.49066	.23136	.61554	.56895	1.00000					
TOC	.49940	.50196	.33945	.34424	.28343	-.01341	.62033	.10831	.44016	1.00000				
TP	.43302	.42730	.33099	.16059	.19859	.06239	.52801	.28567	.59765	.56817	1.00000			
TKN	.53678	.48525	.28942	.16071	.29135	-.04070	.50899	.35197	.56750	.60507	.83682	1.00000		
%<63UM	.81858	.44432	.80884	.67486	.43361	.07292	.84143	.46020	.36847	.65590	.43959	.46618	1.00000	
%<16UM	.88714	.43869	.80554	.65103	.60157	.23334	.87896	.65454	.53824	.53467	.49122	.52392	.89792	1.00000

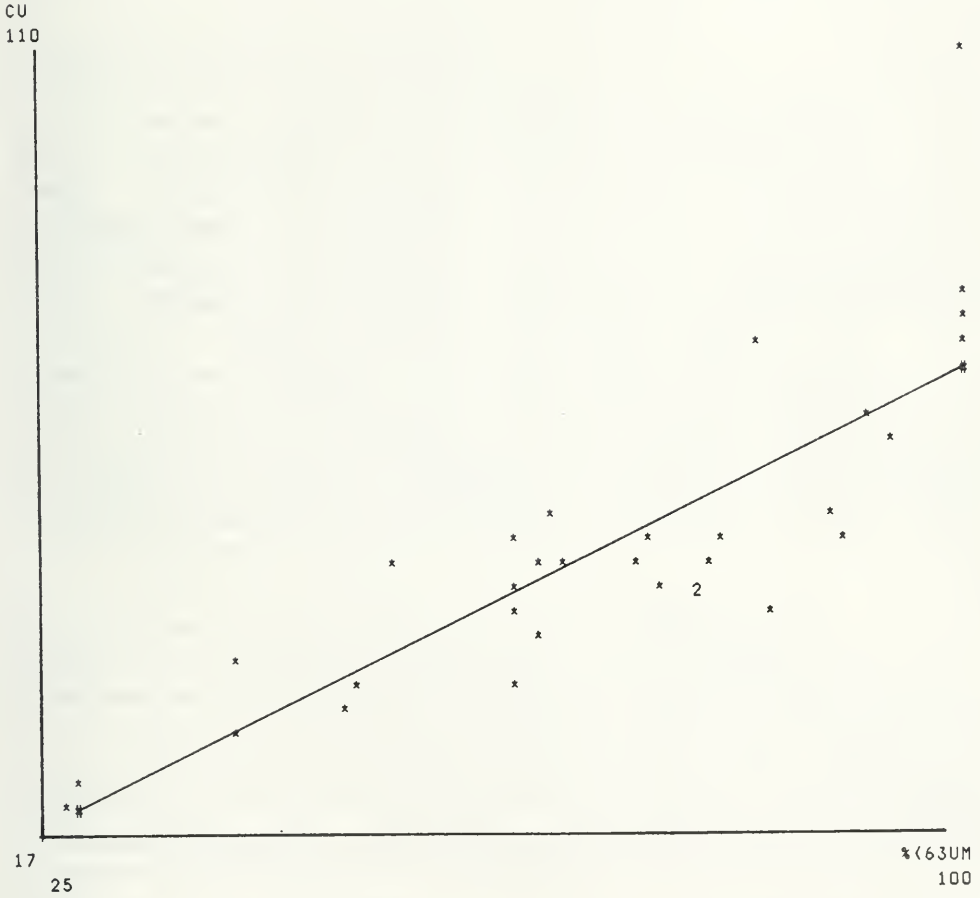
CRITICAL VALUE (2-tail, .05) = +/- .35441

N = 31



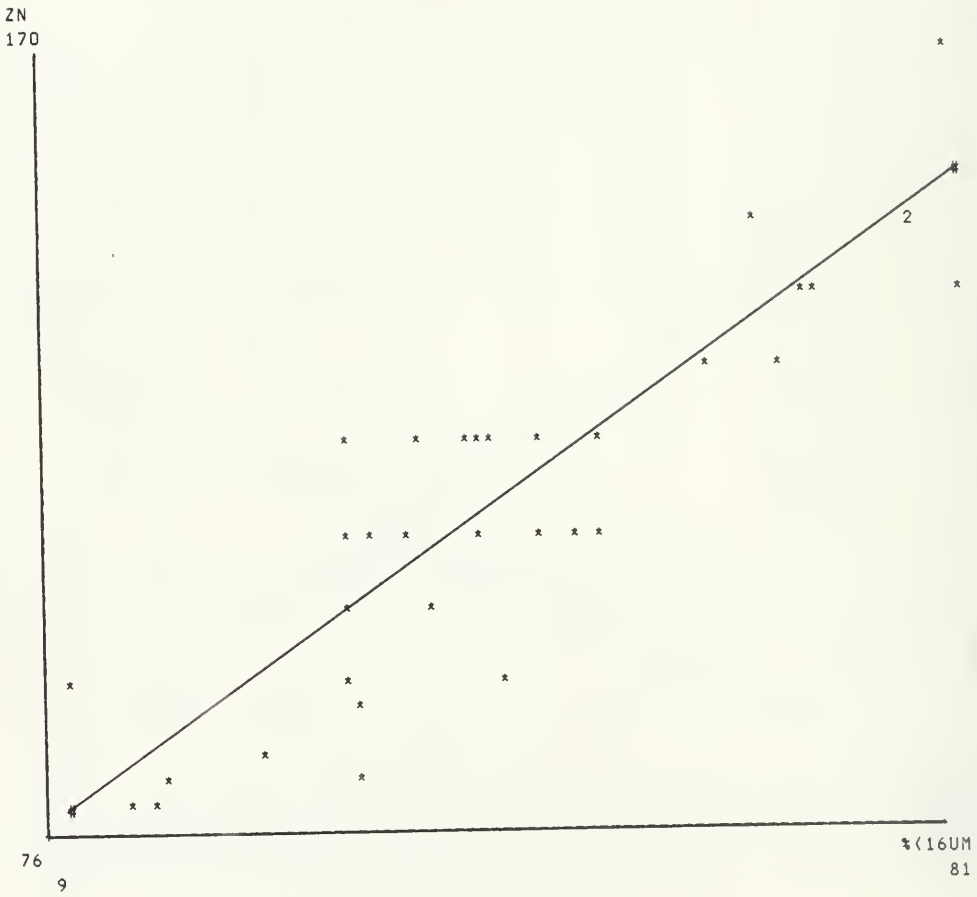
r = .8977 r squared = .8059

FIGURE 3.3.1: ALUMINUM VS % (16 UM



r = .8288 r squared = .6869

FIGURE 3.3.2: COPPER VS % (63 UM



r = .8928 r squared = .7970

FIGURE 3.3.3: ZINC VS % (16 UM

would also affect the Mission River station and no such effect is observable. The offshore station may be reflecting the influence of historically more contaminated sediments as well as the discontinued practice of open water disposal of all dredged material.

3.3.2 Trace Organics in Sediment

Of the 17 organochlorine compounds detected at least once (Table 3.3.2) nine were detected at the mouth of the Mission River, seven at the McKellar River, two at the Kaministiquia River, twelve 2 km offshore, and three 4 km offshore. Of these total PCBs and dieldrin were the only ones with median concentrations greater than the minimum reportable amount at any station. None of the median PCB concentrations exceeded the dredging guideline of 50 ng g^{-1}, and no guidelines yet exist for other organochlorine compounds. Percentage frequencies of PCBs detected above the dredging guideline varied from none at the mouth of the Kaministiquia River to 38 % above the guideline at the station 2 km offshore from the Mission River. This location also had the maximum concentration observed during the study (185 ng g^{-1} on August 14, 1985).

The infrequent detection and low concentrations of most organochlorine compounds suggest that historical loadings to the river are having relatively little measurable effect on sediments in the delta and nearshore area. This may be partly attributable to navigational dredging operations in the area which would have removed and confined contaminated sediments before they migrated to the nearshore zone. In future, it may prove more relevant to the current situation in this area to analyze sediments for pulp and paper related compounds such as chlorophenols, and RFAs (these tests were not available for this study). These data would help establish the existence of any sediment zones affected by pulp and paper discharges and would serve as a tracer to link

effluent discharges to the river system with nearshore sediment conditions.

3.3.3 Sediment Quality Variability

In order to maximise the data available to assess survey-to-survey variability, comparison of station means and survey means was undertaken using data from stations at the mouth of the Mission River, 2 km offshore, and 4 km offshore. Four surveys, with two replicates per survey, over the two year period were available for comparison at these three stations. Given the demonstrated significance of grain size effects, a similar exercise was completed for the grain size corrected metals data (although appropriate data were only available for the first three surveys). The results are presented in Table 3.3.8 .

Based on bulk chemistry data, the differences between station means were generally more significant than the differences between survey means; all parameters other than copper showed significant ($p < 0.05$) station effects. No survey effects were observed for nutrients, however, significant differences between surveys did occur for all metals other than aluminum and iron. There was also significant interaction between station and survey effects for TOC, aluminum, chromium, and zinc.

Normalization of metals concentrations to diminish the effects of grain size (and hence effects of transport and deposition) diminished the number of parameters exhibiting station and survey effects but did not eliminate these effects entirely. Between station differences for chromium, mercury, and zinc were diminished (i.e. were no longer significant), as were between-survey differences for copper, lead (although this may not be meaningful given its poor correlation with grain size), mercury, and zinc. However, significant station effects remained for aluminum, iron, lead, and nickel and significant survey effects

TABLE 3.3.8: SUMMARY OF 2-WAY ANOVA FOR 1985 AND 1986 SEDIMENT QUALITY -- BULK CHEMISTRY AND GRAIN SIZE CORRECTED DATA

	SIGNIFICANT* DIFFERENCE STATIONS		SIGNIFICANT DIFFERENCE SURVEYS		SIGNIFICANT INTERACTION	
PARAMETER	Bulk	Correct.	Bulk	Correct.	Bulk	Correct.
Grain Size (median)	Yes		No		No	
Total P	Yes		No		No	
TKN	Yes		No		No	
TOC	Yes +		No		Yes	
Aluminum	Yes +	Yes	No	Yes +	Yes	No
Chromium	Yes +	No	Yes	Yes +	Yes	Yes
Copper	No	No	Yes	No	No	No
Iron	Yes	Yes +	No	Yes	No	Yes
Lead	Yes +	Yes	Yes	No	No	No
Mercury	Yes	No	Yes +	No	No	No
Nickel	Yes +	Yes	Yes	Yes +	No	No
Zinc	Yes +	No	Yes	No	Yes	No

Comparisons between stations 176, 663, and 668 for all parameters.

* Significant at $p < 0.05$

+ Predominant main effect

were observed for aluminum, chromium, iron, and nickel. The station effects for both bulk and grain size corrected data are clearly attributable to the differences previously discussed. The differences between surveys, on the other hand, follow diverging patterns depending upon whether grain size corrected or bulk chemistry results are examined. For uncorrected chemistry data average metals concentrations tended to decrease from the spring period to the summer period, while for the corrected data the opposite was true. This suggests that there may be a pattern of decreasing sediment quality throughout the summer as a consequence of increases in particulate concentrations of contaminants (specifically aluminum, iron, chromium, and nickel) delivered to the delta area but that this effect is masked by a tendency for sediments to become coarser over the same interval. Interpretation of both station and survey effects requires considerable caution, given the interaction between them for TOC, aluminum, chromium, and zinc, since seasonal fluctuations were not consistent across all stations (or vice versa). The pattern of changes from sprong to summer depends strongly upon the location so that spatial differences cannot be typified by one station.

Future sampling for temporal trend analysis of sediment quality will need to consider separate assessment of the delta and nearshore areas. Long term comparisons should seek depositional locations offshore and should obtain core samples as a means of obtaining additional information concerning temporal variability. High frequency sampling (e.g. monthly) and analysis for particle size at the top of the delta and offshore would assist in the development of an optimum survey design for such an assessment. Separate laboratory analysis of only the silt and clay fraction of the sample may also prove a useful means of isolating temporal effects related to factors other than changes in depositional environment.

Sampling for the purposes of delineating sediment quality zones in the nearshore area should acknowledge the potential for seasonal variability, particularly that related to changes in sediment composition (i.e. as the result of changes in depositional environment). High density, replicate sampling of surficial sediments in the spring and summer is likely to be necessary to ensure that single season results are not mistakenly assumed to represent a typical annual condition. As with temporal trend sampling, separate analysis of the silt and clay fraction may be helpful.

3.4 Centrifuged Water and Sediment

Results of water and suspended sediment analyses for centrifuged samples upstream at the Highway 61 bridge, and downstream at the top of the delta are listed in Tables 3.4.1 and 3.4.2. Survey-by-survey comparison of water quality differences between upstream and downstream samples reveals consistent increases for suspended solids, COND25, alkalinity, sulphate, sodium, TP, TKN, ammonia, aluminum, chromium, iron, zinc, and DHA. In all cases there was a slight decrease in pH. Given the location of the sampling points, these increases are chiefly attributable to discharges into the lower Kaministiquia River of which CPFP is the single largest component.

Comparison of these water quality data with PWQO/G shows TP to exceed the PWQG of 20 ug l^{-1} in one of three upstream samples (maximum concentration 22 ug l^{-1}) and all downstream samples (maximum concentration 64 ug l^{-1}). Despite this evidence of nutrient enrichment in the lower river, nuisance accumulations of algae have not been reported or observed as a problem in this area. Iron exceeded the PWQO of 300 ug l^{-1} in all but one upstream sample (maximum concentration 675 ug l^{-1}) and in all downstream samples (maximum concentration 770 ug l^{-1}).

TABLE 3.4.1: THUNDER BAY CENTRIFUGE 1985/86 RESULTS -- WATER

			STATION 15.0009: HWY 61 BRIDGE				STATION 0802: TOP OF DELTA			
			1985		1986		1985		1986	
PARAMETERS	M.R.A.	P.W.Q.O.	JUNE 8	AUGUST 12	MAY 27	AUGUST 14	JUNE 9	AUGUST 13	JUNE 1	AUGUST 13
Suspended solids (mg/l)	1.0	--	10.0	7.0	--	3.1	15.0	9.0	10.0	7.0
Turbidity (FTU)	0.4	--	5.7	2.8	--	4.3	6.4	3.4	4.7	4.2
Conductivity (uS/cm)	0.3	--	85.0	81.0	--	95.6	158.0	132.0	130.0	256.5
pH	--	--	7.2	7.5	--	8.0	7.0	7.0	7.0	6.8
DOC (mg/l)	0.5	--	14.1	11.8	11.0	10.8	15.4	11.8	--	19.7
Alkalinity (mg/l)	1.4	--	31.0	33.0	--	41.2	38.0	40.0	35.0	45.5
Sulphate (mg/l)	1.8	--	4.7	3.7	--	4.0	14.0	12.3	9.7	27.5
Sodium (mg/l)	0.2	--	2.0	1.5	--	1.9	12.0	8.9	10.0	29.0
Total P (ug/l)	9.0	20 G	22.0	18.0	--	10.5	50.0	59.0	35.0	64.0
TKN (ug/l)	90.0	--	520.0	420.0	--	385.0	670.0	600.0	480.0	610.0
Ammonia (ug/l)	10.0	--	30.0	30.0	--	31.0	60.0	60.0	10.0	70.0
Aluminum (ug/l)	2	--	--	355	340	125	510	400	--	340
Chromium (ug/l)	1	100	--	1	1	ND	9	12	--	27
Copper (ug/l)	1	5	--	5	2	1	3	5	--	3
Iron (ug/l)	50	300	--	675	500	290	770	695	--	470
Mercury (unfilt.) (ng/l)	10	200 T	30	20	ND	ND	10	10	--	10
Nickel (ug/l)	2	25	--	3	ND	ND	ND	2	--	2
Zinc (ug/l)	1	30	--	9	4	5	7	11	--	15
Heptachlor (ng/l)	1	1	--	ND	6	ND	--	ND	--	ND
alpha BHC (ng/l)	1	--	--	ND	3	1	--	ND	--	2
Pentachlorobenzene (ng/l)	1	30	--	ND	ND	ND	--	5	--	ND
2,4,6 Trichlorophenol (ng/l)	50	18000	--	ND	ND	ND	--	ND	--	315
Dehydroabietic acid (ug/l)	10	--	--	ND	ND	ND	--	10	--	26
Oleic acid (ug/l)	10	--	--	ND	ND	ND	--	ND	--	20
Isopimaric acid (ug/l)	10	--	--	ND	ND	ND	--	ND	--	11
Abietic acid (ug/l)	10	--	--	ND	ND	ND	--	ND	--	53

"ND" = NOT DETECTED
"MRA" = MINIMUM REPORTABLE AMOUNT
"---" = NO RESULT AVAILABLE

TABLE 3.4.2: THUNDER BAY CENTRIFUGE 1985/86 RESULTS -- SUSPENDED SEDIMENT

		STATION 15.0009: HWY 61 BRIDGE				STATION 0802: TOP OF DELTA			
		1985		1986		1985		1986	
PARAMETERS	M.R.A.	JUNE 8	AUGUST 12	MAY 27	AUGUST 14	JUNE 9	AUGUST 13	JUNE 1	AUGUST 13
% Loss on Ignition	--	6.4	13.0	9.1	11.0	9.5	24.0	12.0	38.0
TOC (mg/g)	1.00	19.0	43.0	41.0	--	--	73.0	61.0	--
Solvent extractables (ug/g)	10.00	2941	2793	1600	1400	12356	16088	6500	34000
Total P (mg/g)	0.01	0.9	0.8	1.1	1.2	1.9	2.8	1.7	6.1
TKN (mg/g)	0.04	3.2	3.4	4.7	4.7	0.5	9.6	6.6	13.4
Aluminum (ug/g)	10.00	31000	29000	31000	27000	28000	27000	30000	--
Arsenic (ug/g)	0.03	9.1	13.1	8.3	--	6.8	10.6	9.3	--
Cadmium (ug/g)	0.30	3.6	ND	2.0	1.6	3.8	1.3	4.7	--
Chromium (ug/g)	3.00	73	59	88	130	120	140	140	--
Copper (ug/g)	1.00	81	83	87	92	87	88	98	--
Iron (ug/g)	10.00	47000	48000	48000	55000	41000	42000	48000	--
Mercury (ng/g)	0.01	160	120	120	--	--	220	340	--
Nickel (ug/g)	3.00	47	53	46	60	42	44	45	--
Lead (ug/g)	3.00	26	18	21	53	18	29	31	--
Zinc (ug/g)	1.00	130	130	120	170	170	210	260	--
PCB (ng/g)	20	ND	ND	ND	30	40	--	50	60
HCB (ng/g)	1	ND	ND	ND	ND	4	--	ND	3
Dieldrin (ng/g)	2	ND	ND	ND	6	3	--	42	144
Endrin (ng/g)	4	ND	ND	ND	ND	5	--	145	64
Oxychlordane (ng/g)	2	ND	ND	ND	ND	ND	--	78	62
Methoxychlor (ng/g)	5	ND	ND	ND	ND	ND	--	790	ND
Heptachlor epoxide (ng/g)	1	ND	ND	ND	4	ND	--	39	87
Endosulphan I (ng/g)	2	ND	ND	ND	ND	ND	--	7	126
Endosulphan II (ng/g)	4	ND	ND	ND	4	ND	--	58	ND
Endosulphan sulphate (ng/g)	4	ND	ND	ND	4	ND	--	30	ND
alpha BHC (ng/g)	1	ND	ND	ND	ND	ND	--	ND	4
gamma Chlordane (ng/g)	2	ND	ND	ND	ND	ND	--	ND	2

'ND' = NOT DETECTED
'MRA' = MINIMUM REPORTABLE AMOUNT
'---' = NO RESULT AVAILABLE

Heptachlor was detected above the PWQO of 1 ng l^{-1} on one occasion at the upstream location (with a concentration of 6 ng l^{-1}).

A survey-by-survey comparison of results of analysis for centrifuged suspended sediment reveals consistent increases in concentrations of TOC, solvent extractables, %LOI, cadmium, chromium, copper, mercury, zinc, PCBs, dieldrin, and endrin. Concentrations of aluminum and nickel decreased in every case. These findings suggest enrichment of particulate concentrations of most contaminants over the lower river. Additional sampling of effluent point sources would have been beneficial in attributing sources of these enriched particles, particularly if analysis for a pulp and paper effluent tracer (e.g. RFAs, chlorophenols) had been obtained. This type of sampling may be of considerable benefit in linking point source discharges to sediment quality in the delta and nearshore area, and should be undertaken in future.

4. SUMMARY AND CONCLUSIONS

4.1 Water Quality

4.1.1 Comparison with PWQO (and PWQG)

Summary of Conventional Parameters

Iron routinely exceeds the PWQO of 300 ug l^{-1} in a localized zone at river mouth stations. Since this situation also exists upstream at the Highway 61 bridge it is evident that discharges to the lower river are enhancing the naturally high background concentrations. Total phosphorus also routinely exceeds the PWQG of 20 ug l^{-1} at these stations with enrichment occurring in the lower river, however, nuisance accumulations of algae are not a problem in this area. Copper and zinc were occasionally detected

at delta stations with concentrations slightly in excess of their respective PWQO (5 ug l^{-1} and 30 ug l^{-1}).

Summary of Trace Organics

Three organochlorine compounds (heptachlor, endosulphan II, and p,p-DDE) were detected at concentrations above their PWQO. Of these heptachlor was the most widely and frequently observed being detected at all stations with frequencies of from 11% to 50% above the PWQO of 1 ng l^{-1}. The ubiquitous nature of this compound with uniformly low concentrations (maximum of 11 ng l^{-1}) means that it is not possible to identify the Kaministiquia River as a significant source. The DDT metabolite p,p-DDE was detected at only two locations: in one sample at the mouth of the Kaministiquia River (16 ng l^{-1}), and in one sample 4 km offshore from the McKellar River (19 ng l^{-1}). The PWQO for the sum of DDT and metabolites is 3 ng l^{-1}. Endosulphan II was only detected at the mouth of the McKellar River where two samples were detected with concentrations of 6 and 7 ng l^{-1} compared with the PWQO of 3 ng l^{-1}.

Total Resin Acids (TRA) have a pH dependent PWQG of 25 ug l^{-1} (at pH 7.0) and dehydroabietic acid (DHA) has a pH dependent PWQO of 8 ug l^{-1} (at pH 7.0). On August 16, 1985 these pulp mill effluent related compounds were detected grossly in excess of these PWQO/G at the mouth of the Mission River with a DHA concentration of approximately 20 times the objective, and a TRA concentration of approximately 15 times the guideline. Since these extremely high concentrations were only observed at this one location on one occasion it is possible that they resulted from an abnormal discharge from the adjacent Abitibi Mill rather than from upstream discharges. Over the two year survey period DHA concentrations were found slightly in excess of the PWQO at all river mouth stations in from 20 to 40% of the samples. Apart from the August 6, 1985 finding, TRA concentrations slightly

exceeded the guideline on one other occasion at the mouth of the Mission River, and on one occasion (August 12, 1986) at the mouth of the Kaministiquia River

None of the other trace organic compounds examined (chlorophenols, chlorobenzenes, phenoxy acids) were detected at concentrations in excess of their PWQO.

Conclusions

Application of PWQO and PWQG as a means of identifying unacceptable water quality conditions demonstrate the localized nature of water quality impairment. Apart from some enhancement of naturally high iron concentrations in the lower river and delta as the result of effluent discharges, metals present no major source of concern. Eutrophication related parameters such as total phosphorus are clearly not an issue despite a limited zone which fails to meet the PWQG of 20 ug l^{-1}. The detection of several organochlorine compounds, while undesirable, follows a similar pattern to most other areas in the Great Lakes Basin and does not appear to be related to industrial point source discharges in Thunder Bay.

The most significant finding concerns the detection of DHA at river mouth stations. Apart from the August 16, 1985 results which may be attributable to an irregular or accidental discharge, the pattern of concentrations in excess of the toxicity-based PWQO suggests that the capacity of the lower Kaministiquia River to dilute DHA concentrations to acceptable levels is not consistently equal to the loads currently being discharged to it.

4.1.2 Thermal Stratification and Water Quality in the Nearshore Zone

Summary of Temperature and Turbidity

Temperature profiling in the nearshore area identified cold (~7°C) generally isothermal conditions during the late spring, with temperature-depth gradients confined to within 3 km of the delta. By mid August stratified conditions prevail throughout the study area although mean surface water temperatures in the delta area remain slightly warmer than those offshore (18°C versus 15°C).

Concurrent turbidity profiling demonstrated elevated surface turbidity at river mouth stations decreasing with both depth from the surface and distance offshore. The most extensive turbid zone observed during the study occurred during August 1985 where background (open lake) conditions were not reached until ~5 km offshore from the delta.

Summary of Water Quality

Comparison of samples obtained from the depth of maximum turbidity with those from the depth of minimum turbidity showed significant differences ($p < 0.05$) in numerous, conventional water quality parameters (sodium, sulphate, conductivity, BOD5, DOC, total P, TKN, chromium, iron, manganese). This variability in the water column is most pronounced in the immediate delta area.

Conclusions

The similarity between the pattern of temperature and turbidity profiling suggests that thermal density gradients result in poor mixing of river and open-lake water. This creates an extensive zone of turbid surface water emanating from the delta where water quality is poor relative to subsurface conditions.

This situation has important implications for the future selection of sampling procedures for this area, as well as the application of water quality models, since characterization of water quality at stations in the nearshore area will require an appropriate way of eliminating or accommodating this effect. Depending upon the specific objectives of the investigation, this may be achieved by obtaining depth-integrated samples, or by separate sampling in the epilimnion and hypolimnion.

4.1.3 Water Quality Variability

Summary of Station and Survey Effects

Comparison of stations ranging from the top of the delta to 4 km offshore revealed significant ($p < 0.05$) differences among station means for virtually all suitable parameters (i.e only those parameters having all results greater than the minimum reportable amount could be compared). Differences among stations in this area result from the obvious gradient between the delta and nearshore zone and clearly identify the river as the source of contaminants. In the case of BOD5, DOC, and sulphate the highest concentrations were observed at the top of the delta, while for conductivity (25°C), ammonia, total P, and TKN the maximum concentrations were observed at the mouth of the Kaministiquia River downstream from the Thunder Bay STP discharge point.

Seasonal differences were also observed with significant differences ($p < 0.05$) among survey means for many parameters (BOD5, total P, TKN, sulphate, conductivity, alkalinity, ammonia, sodium, DOC, copper, zinc). There was a general tendency for summer survey means to exceed those found in the spring. This was primarily due to seasonal changes at the delta stations: concentrations at the stations 2 km and 4 km offshore remained

relatively constant. The presence of both significant station and survey effects was, however, accompanied by significant ($p < 0.05$) interaction between them for many parameters (total P, TKN, sulphate, conductivity, alkalinity, ammonia, sodium, DOC).

Conclusions

The tendency for conductivity, ammonia, total P, and TKN to exhibit maximum concentrations at the mouth of the Kaministiquia River rather than the top of the delta suggests that the Thunder Bay STP discharge immediately upstream from the river mouth is having a measurable effect on water quality.

The apparent spring to summer increases in concentrations of conventional parameters at the river mouth stations could be caused by a combination of many factors including seasonal (or daily) increases in effluent discharges to the river as well as seasonal reductions in river flow. The August 1986 data were obtained during a period when low flow conditions were artificially maintained in the Kaministiquia River (19 m^3s^{-1} versus 40 m^3s^{-1} in early June) and river mouth results showed a consistent increase over the late May, early June concentrations.

The presence of interaction between station and survey effects means that a reliable, quantitative description of station differences cannot be made on the basis of a single season survey. Nor can seasonal differences be assessed on the basis of just one station. The variability among both seasonal and station effects, and the interaction between them, must be taken into account in the design of future monitoring efforts in this area.

Future water quality surveys should stratify sampling to ensure the greatest spatial coverage in the delta and nearshore area with samples taken at more than one depth. Although relatively

infrequent sampling appears to be adequate to characterize water quality further than 2 km offshore, conditions within the delta are sufficiently variable to require higher frequency sampling for conventional parameters. Since the ability to discern temporal trends will be masked by high variability it may prove useful to combine high frequency (e.g. weekly) sampling at the top of the delta with less intensive (e.g. monthly) sampling approximately 4 km offshore. Such an approach recognizes that the measurable water quality effects of the Kaministiquia River are chiefly confined to a variable zone of surface water generally extending less than 5 km offshore.

4.2 Sediment Quality

4.2.1 Comparison with Dredging Guidelines

Summary

Concentrations of trace metals (iron, chromium, copper, nickel, zinc) exceeded their respective dredging guidelines in virtually all samples at the five sediment sampling stations in the delta and nearshore area. Results for PCBs varied from a low of no concentrations above the dredging guideline of 50 ng g^{-1} at the mouth of the Kaministiquia River to a high of 38 % above the guideline 2 km offshore from the Mission River. This latter station also exhibited the maximum concentration observed during the study (185 ng g^{-1}).

Conclusions

By themselves, the guidelines for open water disposal of dredged material are not a suitable means of identifying areas of unacceptable sediment quality impairment. The elevated metals concentrations found throughout the study area illustrate the interpretational limitations of these guidelines, since these

concentrations are typical of those generally found in sediments of the northern Lake Superior basin. Further biologically based investigations will be required to identify zones having an adverse impact on the aquatic ecosystem: either through toxicity to benthos, or through food web effects.

The relatively low frequency of PCB concentrations in excess of the guideline demonstrates a limited impact from non point-source loadings to the Kaministiquia River on the nearshore zone. Since metals, nutrients, and organochlorine pesticides are not good tracers for pulp and paper mill effluent, it will be necessary in future to analyze samples for chlorophenols and resin, fatty, and aromatic acids (analyses not available for this study) in order to establish a link between upstream pulp mill effluent discharges and sediments in the nearshore zone. Future development of biologically based sediment quality guidelines should recognize the need for pulp and paper related parameters.

4.2.2 Sediment Quality Variability

Summary

Significant differences ($p < 0.05$) among stations were observed for nutrients and all metals other than copper. Generally, maximum concentrations of these parameters occurred at the deeper stations 2 km and 4 km offshore while minimum concentrations were found at the mouth of the Kaministiquia River. Particle sizes followed a similar pattern with fine-grained material at the offshore stations, and coarser sediment at the mouth of the Kaministiquia River.

Significant ($p < 0.05$) linear correlations were found between concentrations of metals and particle size (percentage less than 63 um and 16 um). Normalizing sediment chemistry results for the

percentage less than 63 um reduced the number of metals exhibiting significant concentration differences among stations (i.e. chromium, mercury, and zinc no longer differed significantly) but several remained (aluminum, iron, lead, and nickel). Comparison of station means for grain size corrected metals identified the mouth of the Kaministiquia River and the station 4 km offshore as being the closet to sources of metals.

Significant ($p < 0.05$) differences among surveys were not as prevalent as station effects in that particle size, TOC, total P, and TKN did not differ over the survey periods although several metals (chromium, copper, lead, mercury, nickel, zinc) did. Normalizing metals concentrations for grain size eliminated these significant differences between surveys for copper, lead, mercury, and zinc, but left chromium and nickel unchanged, and created significant ($p < 0.05$) survey effects for aluminum and iron. Average metals concentrations tended to decrease from the spring to summer surveys, however, the opposite trend was apparent for grain size corrected results. Significant ($p < 0.05$) interaction between station and survey effects was observed for several parameters, particularly for bulk chemistry (uncorrected) results.

Conclusions

Applying a grain size correction to sediment chemistry results (for those parameters exhibiting significant correlations between particle size and chemical concentration) will diminish concentration differences arising primarily from differences in depositional environment. This procedure will, therefore, tend to accentuate differences attributable to other factors such as proximity to source. The interpretational utility of future results of laboratory analysis could be enhanced by undertaking additional analyses following separation of the silt-clay fraction. This would provide a direct means of reducing grain

size effects and could be used to confirm predictions of numerical grain size corrections.

The tendency for grain size corrected metals results to have maximum concentrations at the mouth of the Kaministiquia River and the station 4 km offshore suggests that the Thunder Bay STP discharge and the historical open-lake disposal area for dredged material may be exerting an effect on metals concentrations on the fine-grained sediment fraction in this area. There is, however, currently insufficient evidence to suggest that metals concentrations are a matter of primary concern.

The apparently contradictory situation of a spring to summer decrease in bulk metals concentrations on the one hand, and an increase in grain size corrected metals on the other, suggests that seasonal changes in sediment composition may mask changes in contaminant concentrations attributable to discharges. Further interpretation of seasonal variability is inappropriate given the interaction of station and survey effects (since seasonal shifts are not consistent across all stations). Future sediment investigations for the purposes of monitoring temporal trends may find it beneficial to make separate comparisons for the delta and offshore zones. Analysis of core samples from the offshore depositional zone may also be of assistance. High frequency (e.g. monthly) collection of samples from the top of the delta and offshore for particle size analysis may prove helpful in the design of such a study.

4.3 Centrifuged Water and Sediment

Summary
Comparison of whole water samples obtained during centrifuging at the Hwy. 61 bridge with those from the top of the delta

demonstrated consistent increases in concentrations of suspended solids, conductivity, alkalinity, sulphate, sodium, total P, TKN, ammonia, aluminum, chromium, iron, zinc, and dehydroabietic acid (and a decrease in pH). A similar comparison of centrifuged particulate chemistry showed consistent increases in percentage loss on ignition, TOC, solvent extractables, cadmium, chromium, copper, mercury, zinc, PCBs, dieldrin, and endrin. Aluminum and nickel concentrations decreased.

Conclusions

Discharges to the lower Kaministiquia River (of which Canadian Pacific Forest Products is the single greatest) create a measurable degradation in water quality as far downstream as the top of the delta. The combination of increased quantities of suspended solids containing increased contaminant concentrations suggests that particulate loadings of contaminants may account for much of this deterioration in water quality. Additional centrifuge sampling at these upstream-downstream locations are required before sample sizes are sufficient to quantify estimates of aqueous-particulate partitioning and loadings. Future sampling should also include effluent streams at major point sources in the lower river in order to demonstrate their relative contributions.

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APPENDIX A: WATER QUALITY TESTS

Physical and Miscellaneous:	Conductivity (25°C), Suspended Solids, Turbidity, Biochemical Oxygen Demand (5 day), pH, Alkalinity, Sulphate, Sodium
Nutrients:	Total Phosphorus, Total Kjeldahl Nitrogen, Ammonia, Dissolved Organic Carbon
Trace Metals: (unfiltered total)	Iron, Manganese, Aluminum, Arsenic, Cadmium, Chromium, Copper, Mercury, Nickel, Lead, Zinc
Resin, Fatty and Aromatic Acids:	Capric Acid, Lauric Acid, Myristic Acid, Palmitic Acid, Stearic Acid, Oleic Acid, Linoleic Acid, Arachidic Acid, Benzoic Acid, Salicylic Acid, Phthalic Acid, Palustric Acid, Pimaric Acid, Sandaracopimaric Acid, Levopimaric Acid, Isopimaric Acid, Neoabietic Acid, Abietic Acid, Dehydroabietic Acid
Organochlorines:	Total PCBs, Hexachlorobenzene, Heptachlor, Heptachlor Epoxide, Aldrin, Dieldrin, Endrin, Mirex, alpha BHC, beta BHC, gamma BHC (lindane), alpha Chlordane, gamma Chlordane, Oxychlordane, o,p-DDT, p,p-DDT, p,p-DDD, p,p-DDE, Methoxychlor (DMDT), Endosulphan I, Endosulphan II, Endosulphan Sulphate, Octachlorostyrene
Chlorobenzenes:	Hexachloroethane, Hexachlorobutadiene, 1,3,5-Trichlorobenzene, 1,2,4-Trichlorobenzene, 1,2,3-Trichlorobenzene, 2,4,5-Trichlorotoluene, 2,3,6-Trichlorotoluene, 2,6,a-Trichlorotoluene, 1,2,3,5-Tetrachlorobenzene, 1,2,4,5-Tetrachlorobenzene, 1,2,3,4-Tetrachlorobenzene, Pentachlorobenzene
Chlorophenols:	2,4,6-Trichlorophenol, 2,4,5-Trichlorophenol, 2,3,4-Trichlorophenol, 2,3,5,6-Tetrachlorophenol, 2,3,4,5-Tetrachlorophenol, Pentachlorophenol
Phenoxy Acids:	Dicamba, Silvex, Picloram, 2,4,D-Propionic Acid, 2,4,-Dichlorophenoxyacetic Acid, 2,4,-Dichlorophenoxybutyric Acid, 2,4,5-Trichlorophenoxyacetic Acid,

APPENDIX B: WATER QUALITY DATA LISTING

1985 Water Quality Data

STN#	YYMMDD	TIME	DEP#	SAMP#	DISOLVED ORGANIC CARBON MG/L	K'DAHL N TOTAL MG/L	PHOSPHOR UNF.TOT. MG/L	CONDUCT. 25C US/CM	PH	SULPHATE UNF.REAC MG/L	TURB'ITY FTU	ALK TOTAL MG/L	RESIDUE PARTIC. MG/L	5 DAY TOT.DEM. MG/L	AMMONIA MG/L	SODIUM MG/L
0176	850611	0938	0.5	36000	9.4	0.520	0.062	131	7.100	9.630	20	37	45	1.700	0.06	7.7
	850614	1003	5.0	36016	6.5	0.450	0.063	128	7.400	8.060	23	42	55	1.300	0.06	6.5
	850815	1304	2.0	15419	10.2	0.420	0.032	134	7.100	11.800	3.500	42	7	1.900	0.02	8.6
			2.0	15420	M	M	M	M	M	M	M	M	M	M	M	M
		1310	8.0	15421	2.2	0.170	0.010	98	7.600	3.840	1.400	43	5	0.500	0.03	1.9
			8.0	15422	M	M	M	M	M	M	M	M	M	M	M	M
	850816	1448	2.0	15451	10.5	0.520	0.041	164	7.200	14.300	4.600	48	7	1.700	0.02	11.0
			2.0	15452	M	M	M	M	M	M	M	M	M	M	M	M
		1455	9.0	15453	2.1	0.220	0.015	99	7.500	3.810	1.900	43	5	0.500	0.01	2.0
			9.0	15454	M	M	M	M	M	M	M	M	M	M	M	M
0653	850611	1111	1.0	36003	3.0	0.150	0.003	104	7.400	4.370	0.750	41	1	0.700	0.01	2.6
			1.0	36004	2.7	0.160	0.002	104	7.400	4.370	0.750	41	1	0.700	0.01	2.6
		1115	12.0	36005	2.3	0.150	0.004	103	7.400	4.970	0.650	41	1	0.800	0.01	2.1
	850614	1130	4.0	36019	2.2	0.150	0.001	104	7.600	3.890	0.450	47	1	0.700	0.01	2.2
			4.0	36020	2.2	0.160	0.001	103	7.600	3.920	0.500	42	1	0.600	0.01	2.1
		1135	19.0	36021	1.8	0.160	0.001	103	7.600	3.610	0.400	45	1	0.500	0.01	2.9
	850816	1205	4.0	15459	2.0	0.150	0.006	98	7.700	3.810	0.700	43	1	0.400	0.02	1.9
	850816	1205	4.0	15460	M	M	M	M	M	M	M	M	M	M	M	M
0663	850611	1041	0.5	36001	3.4	0.240	M	M	M	M	M	M	M	M	M	M
		1045	8.0	36002	2.8	0.170	M	M	M	M	M	M	M	M	M	M
	850614	1201	0.5	36017	4.2	0.310	M	M	M	M	M	M	M	M	M	M
		1205	7.0	36018	2.2	0.150	M	M	M	M	M	M	M	M	M	M
	850815	1453	5.0	15423	M	0.200	0.011	116	7.300	5.040	1.500	41	2	1.000	0.01	4.4
			5.0	15424	M		0.005	110	7.400	4.560	1.200	42	1	0.900	0.01	3.3
		1500	1.0	15425	M	0.130	0.015	128	7.500	6.830	2.600	42	3	0.800	0.04	5.7
			1.0	15426	M		0.001	105	7.500	3.950	0.800	41	1	0.800	0.01	2.5
	850816	1528	8.0	15455	2.1	0.180	0.014	103	7.600	4.770	2.200	43	6	0.500	0.02	2.6
			8.0	15456	M		0.003	97	7.900	3.630	0.450	42	1	0.300	0.02	1.9
		1540	2.0	15458	M		0.007	101	7.600	4	0.950	43	1	0.400	0.02	1.9
			2.0	15457	2.0	0.160	0.006	98	7.700	3.640	0.450	43	1	0.300	0.01	1.8
			1.0	15463	M	M	M	M	M	M	M	M	M	M	M	M

STN#	YYMMDD	TIME	DEP#	SAMP#	DISOLVED ORGANIC CARBON MG/L	K'DAHL N TOTAL MG/L	PHOSPHOR UNF.TOT. MG/L	CONDUCT. 25C US/CM	PH	SULPHATE UNF.REAC MG/L	TURB'ITY FTU	ALK TOTAL MG/L	RESIDUE PARTIC. MG/L	5 DAY TOT.DEM. MG/L	AMMONIA MG/L	SODIUM MG/L
0668	850611	1257	0.5	36010	2.0	0.140	0.002	101	7.500	3.780	0.500	41	1	0.800	0.01	1.9
		1259	15.0	36011	1.8	0.100	0.001	100	7.500	3.640	0.450	41	<1	0.500	0.01	1.7
	850614	1300	4.5	36026	1.8	0.150	0.001	101	7.500	3.580	0.350	41	7	0.600	0.01	5.7
		1305	14.0	36027	1.6	0.140	0.006	101	7.500	3.530	0.350	42	1	0.600	0.01	1.7
	850815	1227	5.0	15414	2.2	0.160	0.013	98	7.800	3.870	0.700	43	1	0.300	0.02	2.0
			5.0	15415	2.0	0.170	0.008	99	7.700	3.870	0.800	43	1	0.300	0.02	2.0
			5.0	15416	M	M	M	M	M	M	M	M	M	M	M	M
		1230	14.0	15417	1.6	0.120	0.005	98	7.600	3.520	0.700	44	1	0.200	0.02	1.6
			14.0	15418	M	M	M	M	M	M	M	M	M	M	M	M
	850816	1314	6.0	15446	2.3	0.200	0.008	100	7.600	4.030	0.950	43	1	0.300	0.02	2.3
			6.0	15447	2.4	0.200	0.009	100	7.600	4.120	0.950	43	1	0.400	0.02	2.3
			6.0	15448	M	M	M	M	M	M	M	M	M	M	M	M
0671	850611	1222	1.0	36009	9.7	0.620	0.053	144	7.200	9.930	5.100	41	9	2.000	0.13	9.6
	850614	1225	3.5	36025	4.1	0.460	0.037	129	7.300	6.020	5.800	42	7	0.900	0.17	5.7
	850815	1153	2.0	15412	8.0	0.540	0.048	131	7.100	9.980	3.100	43	6	1.600	0.11	7.0
			2.0	15413	M	M	M	M	M	M	M	M	M	M	M	M
	850816	1246	1.0	15444	5.6	0.530	0.043	145	7.200	11.100	2.900	47	5	1.400	0.08	7.8
			1.0	15445	M	M	M	M	M	M	M	M	M	M	M	M
0677	850611	1322	0.5	36012	9.7	0.700	0.065	148	7.100	9.990	4.800	41	8	2.500	0.16	10.0
	850614	1336	1.5	36028	6.0	1.800	0.110	192	7.000	11.140	5.300	48	8	2.600	1.10	9.9
	850815	1053	2.0	15408	8.8	0.850	0.078	152	7.000	10.900	4.000	44	8	2.500	0.19	8.0
			2.0	15409	M	M	M	M	M	M	M	M	M	M	M	M
		1058	8.0	15410	1.8	0.160	0.008	98	7.300	3.550	0.750	43	1	0.300	0.02	1.6
			8.0	15411	M	M	M	M	M	M	M	M	M	M	M	M
	850816	1351	8.0	15440	3.0	0.340	0.054	108	7.600	4.740	7.300	45	30	0.700	0.03	2.8
			8.0	15441	M	M	M	M	M	M	M	M	M	M	M	M
		1357	1.0	15442	4.0	0.520	0.047	136	7.300	8.190	2.500	47	8	0.900	0.13	4.9
			1.0	15443	M	M	M	M	M	M	M	M	M	M	M	M

STN#	YYMMDD	TIME	DEP#	SAMP#	DISOLVED - ORGANIC CARBON MG/L	K'DAHL N TOTAL MG/L	PHOSPHOR UNF.TOT. MG/L	CONDUCT. 25C US/CM	PH	SULPHATE UNF.REAC MG/L	TURB'ITY FTU	ALK TOTAL MG/L	RESIDUE PARTIC. MG/L	5 DAY TOT.DEM. MG/L	AMMONIA MG/L	SODIUM MG/L
0791	850611	1417	1.0	36013	1.6	0.130	0.003	98	7.700	3.410	0.300	41	1	0.400	0.01	1.5
	850614	1433	1.0	36029	1.6	0.160	0.001	101	7.600	3.530	0.350	42	1	0.600	0.02	1.7
	850815	0955	1.0	15406	2.0	0.150	0.007	97	7.600	3.600	0.350	42	1	0.200	0.02	1.7
			1.0	15407	M	M	M	M	M	M	M	M	M	M	M	M
	850816	1112	9.0	15438	1.8	0.130	0.002	97	7.800	3.700	0.500	43	1	0.200	0.01	1.7
0795	850611	1135	19.0	36006	2.0	0.160	0.004	102	7.500	3.970	0.550	41	1	0.800	0.01	2.1
			19.0	36007	2.0	0.150	0.004	101	7.500	3.890	0.500	41	1	0.900	0.01	2.1
		1140	19.0	36008	2.3	0.170	0.004	100	7.600	4.060	0.550	41	1	0.800	0.01	2.2
	850614	1102	4.0	36023	2.3	0.180	0.001	104	7.500	4.030	0.500	41	1	0.800	0.01	2.3
		1110	19.0	36024	1.8	0.140	0.001	102	7.500	3.690	0.450	41	1	0.600	0.01	1.9
		1205	4.0	36022	2.3	0.190	0.001	103	7.600	4.070	0.500	41	1	0.600	0.02	2.3
	850816	1142	9.0	15461	1.8	0.230	0.006	97	7.800	3.610	0.650	43	1	0.300	0.01	1.8
			9.0	15462	M	M	M	M	M	M	M	M	M	M	M	M

STN#	YYMMDD	TIME	DEP#	SAMP#	IRON MG/L	CHROMIUM MG/L	COPPER MG/L	MERCURY UG/L	NICKEL MG/L	LEAD MG/L	ALUMINUM MG/L	ZINC MG/L
0176	850611	0938	0.5	36000	1.500	0.007	0.005	0.01	0.002	0.004	1.200	0.007
	850614	1003	5.0	36016	2.600	0.009	0.006	0.01	0.003	0.003	M	0.021
	850815	1304	2.0	15419	0.530	0.010	0.001	0.01	0.002	0.003	0.280	0.007
			2.0	15420	0.550	0.010	0.003	M	0.002	0.003	0.320	0.008
		1310	8.0	15421	0.200	0.001	0.001	0.01	0.002	0.003	0.120	0.005
			8.0	15422	0.160	0.001	0.001	M	0.002	0.003	0.110	0.002
	850816	1448	2.0	15451	0.510	0.009	0.001	0.01	0.002	0.003	0.290	0.001
			2.0	15452	0.530	0.009	0.001	M	0 001	0.003	0.300	0.001
		1455	9.0	15453	0.120	0.001	0.001	0.01	0.001	0.003	0.049	0.001
			9.0	15454	0.100	0.001	0.001	M	0.001	0.003	M	0.001
0653	850611	1111	1.0	36003	0.067	0.001	0.002	0.01	0.002	0.003	0.056	ND
			1.0	36004	0.054	0.001	0.001	0.01	0.002	0.003	0.040	0.002
		1115	12.0	36005	0.046	0.001	ND	0.01	0.002	0.003	0.033	0.003
	850614	1130	4.0	36019	0.045	0.002	0.002	0.01	0.001	0.003	M	0.005
			4.0	36020	0.041	0.001	0.002	0.01	0.002	0.003	M	0.005
		1135	19.0	36021	0.027	0.001	0.002	0.01	0.001	0.003	M	0.003
	850816	1205	4.0	15459	0.040	0.001	0.001	0.01	0.001	0.003	0.010	0.002
	850816	1205	4.0	15460	0.041	0.001	0.001	M	0.001	0.003	0.015	0.001
0663	850611	1041	0.5	36001	0.130	0.001	0.002	0.01	0.002	0.003	0.076	ND
		1045	8.0	36002	0.100	0.001	0.002	0.01	0.002	0.003	0.064	0.002
	850614	1201	0.5	36017	0.280	0.003	0.003	0.01	0.001	0.003	M	0.008
		1205	7.0	36018	0.075	0.002	0.002	0.01	0.001	0.003	M	0.004
	850815	1453	5.0	15423	0.300	0.002	0.003	0.01	0.002	0.003	0.210	0.004
			5.0	15424	0.004	0.001	ND	M	0.002	0.003	0.004	0.002
		1500	1.0	15425	0.030	0.001	0.003	0.01	0.002	0.003	0.015	0.008
			1.0	15426	0.030	0.001	0.003	M	0.002	0.003	0.007	0.004
	850816	1528	8.0	15455	0.070	0.001	0.001	0.01	0.001	0.003	0.020	0.001
			8.0	15456	0.053	0.001	0.001	M	0.001	0.003	0.018	0.001
		1540	2.0	15458	0.030	0.001	0.001	M	0.001	0.003	0.002	0.001
			2.0	15457	0.025	0.001	0.001	0.01	0.001	0.003	0.008	0.001
			1.0	15463	M	M	M	M	M	M	M	M

STN#	YYMMDD	TIME	DEP#	SAMP#	IRON MG/L	CHROMIUM MG/L	COPPER MG/L	MERCURY UG/L	NICKEL MG/L	LEAD MG/L	ALUMINUM MG/L	ZINC MG/L
0668	850611	1257	0.5	36010	0.025	0.001	ND	0.01	0.002	0.003	0.022	0.002
		1259	15.0	36011	0.020	0.001	ND	0.01	0.002	0.003	0.025	0.001
	850614	1300	4.5	36026	0.017	0.004	0.002	0.01	0.001	0.003	M	0.039
		1305	14.0	36027	0.160	0.001	ND	0.01	0.001	0.003	M	ND
	850815	1227	5.0	15414	0.060	0.002	0.004	0.01	0.002	0.003	0.022	0.002
			5.0	15415	0.058	0.001	0.003	0.01	0.002	0.003	0.024	0.002
			5.0	15416	0.070	0.001	0.001	M	0.002	0.003	0.028	0.002
		1230	14.0	15417	0.041	0.001	0.004	0.01	0.002	0.003	0.016	0.003
			14.0	15418	0.042	0.001	0.004	M	0.002	0.003	0.018	0.002
	850816	1314	6.0	15446	0.093	0.001	0.001	0.01	0.002	0.003	0.019	0.004
			6.0	15447	0.090	0.001	0.001	0.01	0.002	0.003	0.017	0.002
			6.0	15448	0.074	0.001	0.001	M	0.002	0.003	0.015	ND
0671	850611	1222	1.0	36009	0.530	0.006	0.002	0.01	0.002	0.003	0.300	0.005
	850614	1225	3.5	36025	0.640	0.017	0.003	0.01	0.001	0.003	M	0.150
	850815	1153	2.0	15412	0.560	0.008	0.004	0.01	0.002	0.003	0.230	0.006
			2.0	15413	0.550	0.008	0.004	M	0.002	0.003	0.220	0.004
	850816	1246	1.0	15444	0.370	0.005	0.001	0.01	0.002	0.003	0.080	0.002
			1.0	15445	0.450	0.006	0.001	M	0.002	0.003	0.097	0.003
0677	850611	1322	0.5	36012	0.570	0.005	0.002	0.01	0.002	0.003	0.300	0.005
	850614	1336	1.5	36028	1.100	0.003	0.003	0.02	0.002	0.004	M	0.009
	850815	1053	2.0	15408	0.700	0.008	0.005	0.01	0.002	0.003	0.230	0.007
			2.0	15409	0.670	0.008	0.003	M	0.002	0.003	0.230	0.006
		1058	8.0	15410	M	M	M	M	M	M	M	M
			8.0	15411	0.070	0.002	0.003	M	0.002	0.003	0.030	0.002
	850816	1351	8.0	15440	0.930	0.003	0.002	0.01	0.002	0.003	0.200	0.005
			8.0	15441	0.830	0.002	0.002	M	0.002	0.003	0.170	0.004
		1357	1.0	15442	0.670	0.005	0.001	0.01	0.002	0.003	0.074	0.002
			1.0	15443	0.370	0.004	0.001	M	0.002	0.003	0.056	0.002

STN#	YYMMDD	TIME	DEP#	SAMP#	IRON MG/L	CHROMIUM MG/L	COPPER MG/L	MERCURY UG/L	NICKEL MG/L	LEAD MG/L	ALUMINUM MG/L	ZINC MG/L
0791	850611	1417	1.0	36013	0.012	0.001	0.001	0.02	0.002	0.003	0.017	0.002
	850614	1433	1.0	36029	0.013	0.001	0.001	0.02	0.002	0.003		0.015
	850815	0955	1.0	15406	0.020	0.001	0.004	0.02	0.002	0.003	0.004	0.003
			1.0	15407	M	M	M	M	M	M	0.012	M
	850816	1112	9.0	15438	0.025	0.001	0.001	0.01	0.002	0.003	0.004	ND
0795	850611	1135	19.0	36006	0.033	0.001	ND	0.01	0.002	0.003	0.031	0.001
			19.0	36007	0.034	0.001	0.001	0.01	0.002	0.003	0.032	0.002
		1140	19.0	36008	0.040	0.001	0.001	0.01	0.002	0.003	0.032	0.002
	850614	1102	4.0	36023	0.052	M	0.003	0.01	0.001	0.003	M	M
		1110	19.0	36024	0.052	M	0.004	0.01	0.001	0.004	M	M
		1205	4.0	36022	0.045	0.001	0.002	0.01	0.001	0.003	M	0.003
	850816	1142	9.0	15461	0.033	0.001	0.001	0.01	0.001	0.003	0.008	0.001
			9.0	15462	0.032	0.001	0.001	M	0.001	0.003	0.010	0.001

1986 Water Quality Data

STN#	YYMMDD	TIME	SAMP#	SMPLE DEPTH M	BOD5 MG/L	SUSP SOLIDS MG/L	TOTAL KJELDAHL NITROGEN MG/L	TOTAL PHOSPH MG/L	TURB FTU	SULFATE MG/L	COND25 US/CM	ALKAL MG/L	FREE AMMONIA MG/L	SODIUM MG/L	PH	DISS ORG CARBON MG/L
0176	860531	1026	16488	1.0	2.0	7.0	0.42	0.029	3.80	10.30	126	36	0.01	9.3	7.1	11.1
		1035	16489	1.0	2.0	7.0	0.42	0.027	3.70	10.20	126	35	0.01	8.7	7.1	11.4
		1040	16490	8.0	0.6	25.0	0.26	0.031	6.40	4.61	103	41	0.02	2.8	7.3	3.8
		1045	16491	8.0	0.5	25.0	0.29	0.033	6.20	4.59	103	42	0.02	2.8	7.3	4.1
	860602	1135	16534	1.0	2.1	7.0	0.46	0.031	3.80	12.10	138	36	0.01	11.0	7.1	12.2
		1140	16535	1.0	1.9	6.0	0.44	0.029	3.80	12.10	138	36	0.01	11.0	7.1	11.8
		1145	16536	8.0	0.3	7.0	0.24	0.019	2.80	4.22	101	41	0.01	2.5	7.5	3.4
		1150	16537	8.0	0.6	9.0	0.23	0.018	2.70	4.28	101	41	0.01	2.4	7.5	3.1
	860812	1024	52631	1.5	2.2	4.0	0.42	0.030	2.80	15.70	174	45	0.05	16.0	7.2	11.0
		1034	52632	1.5	2.5	4.0	0.50	0.032	2.60	16.10	174	45	0.05	15.0	7.1	10.8
		1041	52633	6.0	1.2	4.0	0.37	0.017	2.10	8.09	144	46	0.04	10.0	7.5	5.5
		1050	52634	6.0	1.1	4.0	0.30	0.017	2.20	8.40	158	46	0.03	10.0	7.4	5.2
	860815	0923	52665	1.5	4.2	5.0	0.56	0.055	3.60	19.50	219	47	0.09	24.0	7.0	13.5
		0927	52666	1.5	2.8	5.0	0.52	0.055	3.60	20.00	222	48	0.09	24.0	7.2	13.1
		0932	52667	8.0	0.3	4.0	0.22	0.017	1.90	3.98	104	44	0.03	2.5	7.5	2.5
		0937	52668	8.0	0.3	4.0	0.26	0.021	2.00	3.95	104	45	0.02	2.5	7.5	3.7
0653	860602	0846	16544	1.0	0.6	1.0	0.18	0.005	0.55	3.71	99	42	0.01	2.1	7.8	2.6
		0855	16545	1.0	0.4	1.0	0.16	0.005	0.55	3.85	99	41	0.01	2.0	7.8	2.5
	860812	0958	52629	1.5	0.5	1.0	0.18	0.003	0.50	3.36	102	46	0.01	1.9	8.1	2.3
		1008	52630	1.5	0.8	1.0	0.17	0.003	0.50	3.39	102	46	ND	1.9	8.1	6.0
	860815	0815	52661	1.0	0.4	1.0	0.29	0.006	0.65	3.92	102	44	0.01	2.3	7.7	2.7
		0820	52662	1.0	0.9	1.0	0.19	0.007	0.70	3.98	103	44	0.01	2.3	7.7	2.3
0663	860531	1106	16492	1.0	0.5	2.0	0.24	0.010	1.10	4.02	100	42	0.01	2.2	7.5	3.0
		1110	16493	1.0	0.6	1.0	0.20	0.009	1.10	3.94	100	42	0.01	2.2	7.3	3.0
		1115	16494	8.0	0.6	2.0	0.20	0.019	1.10	4.02	100	41	0.01	2.2	7.5	3.0
		1120	16495	8.0	0.5	2.0	0.21	0.008	2.40	4.05	100	42	0.01	2.2	7.4	3.0
	860602	1155	16538	1.0	1.1	3.0	0.33	0.018	2.30	6.87	114	39	0.01	5.4	7.6	6.3
		1200	16539	1.0	1.2	3.0	0.32	0.017	2.30	7.04	114	39	0.01	5.5	7.3	6.3
		1205	16540	7.0	0.8	2.0	0.23	0.015	1.20	4.70	103	41	0.01	2.9	7.5	3.4
		1210	16541	7.0	0.8	2.0	0.22	0.012	1.40	4.90	104	41	0.01	3.2	7.6	3.1
	860812	1150	52637	1.5	0.9	2.0	0.22	0.011	0.80	4.79	107	46	0.01	3.1	7.9	3.6
		1155	52638	1.5	1.0	2.0	0.35	0.008	0.75	4.79	107	46	ND	3.1	7.9	3.4
		1159	52639	5.0	0.6	1.0	0.42	0.012	0.85	4.55	106	44	0.02	2.9	8.0	3.2
		1205	52640	5.0	0.7	1.0	0.20	0.007	0.80	4.28	105	44	ND	2.8	7.9	2.8
	860815	1002	52669	1.5	0.4	1.0	0.16	0.006	0.55	3.67	100	44	0.01	2.0	7.7	2.9
		1007	52670	1.5	0.6	1.0	0.17	0.004	0.70	3.70	100	44	0.01	2.0	7.8	2.7
		1012	52671	6.0	0.7	1.0	0.19	0.008	0.65	3.89	103	44	0.02	2.4	7.6	3.4
		1017	52672	6.0	0.6	1.0	0.38	0.007	0.70	4.00	102	47	0.01	2.3	7.7	3.1

STN#	YYMMDD	TIME	SAMP#	SMPLE DEPTH M	BOD5 MG/L	SUSP SOLIDS MG/L	TOTAL KJELDAHL NITROGEN MG/L	TOTAL PHOSPH MG/L	TURB FTU	SULFATE MG/L	COND25 US/CM	ALKAL MG/L	FREE AMMONIA MG/L	SODIUM MG/L	PH	DISS ORG CARBON MG/L
0668	860531	0858	16482	1.0	0.2	1.0	0.17	0.006	0.70	4.02	99	41	0.01	2.3	7.5	2.9
		0905	16483	1.0	0.2	1.0	0.17	0.005	0.65	4.19	100	43	0.01	2.3	7.5	3.0
		0910	16484	8.0	0.1	7.0	0.18	0.005	0.75	4.11	99	41	0.01	2.2	7.5	3.1
		0915	16485	8.0	0.4	1.0	0.16	0.010	0.90	4.05	99	41	0.01	2.2	7.4	2.8
	860602	1035	16528	1.0	0.3	1.0	0.20	0.006	0.75	4.11	100	45	0.01	2.3	7.7	2.9
		1040	16529	1.0	0.6	1.0	0.20	0.006	0.80	4.08	100	43	0.01	2.3	7.7	3.0
		1045	16530	8.0	0.6	1.0	0.19	0.004	0.65	3.88	99	41	0.01	2.1	7.6	2.9
		1050	16531	8.0	0.5	1.0	0.19	0.006	0.70	3.97	99	41	0.01	2.3	7.7	2.8
	860812	1326	52645	1.5	0.6	1.0	0.18	0.003	0.55	3.85	101	44	0.01	2.1	7.8	3.5
		1330	52646	1.5	0.5	1.0	0.18	0.003	0.50	3.79	102	44	0.01	2.3	8.1	2.7
		1335	52647	5.0	0.6	2.0	0.19	0.004	0.55	3.69	102	44	ND	2.1	8.1	2.9
		1340	52648	5.0	0.6	1.0	0.17	0.002	0.65	3.72	101	44	ND	2.2	8.0	2.6
	860815	1116	52677	1.5	0.3	1.0	0.17	0.005	0.40	3.58	99	44	0.01	2.0	7.9	2.7
		1121	52678	1.5	0.5	1.0	0.17	0.004	0.45	3.56	100	44	0.01	1.9	7.8	3.0
		1126	52679	8.0	0.1	1.0	0.18	0.007	0.55	3.68	100	44	0.01	1.9	7.6	4.0
		1131	52680	8.0	0.2	1.0	0.17	0.007	0.65	3.65	99	44	0.01	1.9	7.6	2.6
0671	860530	1105	16475	1.0	1.0	5.0	0.44	0.030	2.50	6.65	111	42	0.04	5.0	7.1	6.8
		1110	16476	1.0	1.0	6.0	0.44	0.031	2.20	6.71	111	39	0.05	5.0	7.1	7.0
		1115	16477	5.0	0.6	7.0	0.40	0.030	3.41	4.33	104	48	0.16	2.4	7.1	3.1
		1120	16478	5.0	0.5	6.0	0.39	0.028	2.40	4.42	104	44	0.16	2.5	7.3	3.1
	860602	0955	16523	1.0	2.0	6.0	0.54	0.048	3.20	10.70	133	38	0.11	9.9	7.2	9.1
		1000	16524	1.0	1.9	6.0	0.56	0.048	3.60	10.90	133	38	0.12	9.7	7.1	9.8
		1005	16525	5.0	0.8	5.0	0.32	0.021	2.50	5.18	107	42	0.05	3.4	7.5	4.0
		1010	16526	5.0	0.8	5.0	0.32	0.021	2.50	5.18	107	42	0.05	3.4	7.5	3.6
	860812	1229	52641	1.5	1.3	3.0	0.50	0.040	2.10	8.85	136	44	0.12	9.4	7.3	7.9
		1234	52642	1.5	1.4	3.0	0.43	0.034	1.80	9.02	135	45	0.12	8.6	7.3	7.2
		1240	52643	5.0	0.9	3.0	0.40	0.020	1.80	6.30	120	44	0.06	5.4	7.7	5.0
		1245	52644	5.0	1.1	3.0	0.31	0.020	1.90	6.87	122	44	0.05	5.4	7.6	4.9
	860815	1040	52673	1.5	3.2	3.0	0.61	0.072	3.00	16.80	202	47	0.18	19.0	7.1	12.1
		1045	52674	1.5	2.0	2.0	0.73	0.054	2.30	13.60	178	46	0.13	14.0	7.1	11.2
		1050	52675	6.0	0.4	2.0	0.24	0.017	1.60	4.06	104	44	0.07	2.5	7.4	3.7
		1055	52676	6.0	0.6	2.0	0.29	0.023	1.70	4.12	104	44	0.07	2.5	7.4	3.0

STN#	YYMMDD	TIME	SAMP#	SMPLE DEPTH M	BOD5 MG/L	SUSP SOLIDS MG/L	TOTAL KJELDAHL NITROGEN MG/L	TOTAL PHOSPH MG/L	TURB FTU	SULFATE MG/L	COND25 US/CM	ALKAL MG/L	FREE AMMONIA MG/L	SODIUM MG/L	PH	DISS ORG CARBON MG/L
0677	860530	1020	16471	1.0	1.3	7.0	0.46	0.034	2.40	7.68	114	37	0.01	6.3	6.9	9.6
		1025	16472	1.0	1.3	7.0	0.50	0.037	2.70	7.57	114	37	0.04	5.9	7.0	9.6
		1030	16473	8.0	0.4	3.0	0.18	0.010	1.60	3.74	098	46	0.01	1.8	7.5	2.2
		1035	16474	8.0	0.5	3.0	0.17	0.007	1.50	3.56	098	44	0.01	1.8	7.5	2.7
	860602	0916	16519	1.0	2.0	7.0	0.62	0.061	3.70	10.30	132	39	0.14	9.1	7.1	10.0
		0920	16520	1.0	2.1	6.0	0.64	0.064	3.70	10.80	135	39	0.14	10.0	7.0	9.6
		0925	16521	8.0	0.6	4.0	0.22	0.015	1.60	3.81	100	48	0.01	2.0	7.5	2.9
		0930	16522	8.0	0.9	4.0	0.24	0.020	1.80	3.80	100	42	0.01	2.0	7.5	2.6
	860812	1420	52649	5.0	4.6	9.0	5.50	0.260	8.10	9.12	196	58	1.90	12.0	7.0	5.9
		1424	52650	5.0	4.9	9.0	2.50	0.200	1.50	6.20	193	55	1.50	10.0	7.0	5.8
		1428	52651	8.0	1.0	5.0	0.42	0.033	2.80	4.61	113	46	0.20	3.3	7.6	3.9
		1432	52652	8.0	0.9	7.0	0.69	0.060	4.00	5.04	123	47	0.36	4.3	7.3	3.2
	860815	1149	52681	1.5	3.4	3.0	0.79	0.069	2.10	9.56	156	47	0.38	9.4	7.3	6.6
		1154	52682	1.5	3.0	3.0	1.10	0.076	2.60	10.90	165	47	0.41	11.0	7.1	7.0
		1159	52683	4.5	0.8	2.0	0.60	0.014	1.00	4.07	103	44	0.02	2.5	7.7	2.2
		1204	52684	4.5	0.7	2.0	0.20	0.009	0.95	4.12	104	45	0.01	2.5	7.7	2.1
0791	860530	0852	16469	1.0	0.2	1.0	0.14	0.003	0.40	3.68	097	43	0.01	1.8	7.7	M
		0915	16470	1.0	0.3	1.0	0.14	0.004	0.45	3.56	098	43	0.01	1.8	7.5	2.4
	860602	0747	16517	1.0	0.5	1.0	0.16	0.003	0.35	3.38	097	44	0.01	1.6	7.8	2.0
	860812	0905	52625	1.5	0.4	1.0	0.17	0.003	0.40	3.49	104	45	0.03	2.1	8.1	3.4
		0910	52626	1.5	0.5	1.0	0.16	0.002	0.60	3.53	102	45	0.01	2.1	8.1	2.6
	860815	0745	52657	1.5	0.6	1.0	0.16	0.004	0.45	3.75	098	44	0.01	1.9	7.9	3.7
		0750	52658	1.5	0.3	1.0	0.42	0.004	0.40	3.70	100	44	0.01	2.0	7.6	3.6
0795	860602	0824	16542	1.0	0.6	1.0	0.22	0.012	1.40	4.90	104	41	0.01	3.2	7.6	2.7
		0830	16543	1.0	0.6	1.0	0.17	0.004	0.50	3.91	099	43	0.01	2.2	7.7	2.9
	860812	0941	52627	1.5	0.4	1.0	0.30	0.004	0.50	3.32	102	46	0.02	2.0	8.1	3.4
		0951	52628	1.5	0.4	1.0	0.18	0.004	0.45	3.32	102	46	0.01	2.1	8.1	4.6
	860815	0814	52659	1.5	0.4	1.0	0.18	0.006	0.45	3.81	101	44	0.01	2.0	7.7	3.6
		0824	52660	1.5	0.7	1.0	0.23	0.005	0.55	3.70	101	44	0.01	2.0	7.8	2.4
0802	860531	0957	16486	1.0	2.6	8.0	0.47	0.035	3.80	12.10	135	34	0.01	11.0	7.0	14.6
		1005	16487	1.0	2.6	8.0	0.47	0.035	3.30	12.20	135	34	0.01	12.0	7.0	14.8
	860602	1110	16532	1.0	3.9	15.0	0.51	0.042	6.80	14.90	148	36	0.01	13.0	7.1	13.7
		1115	16533	1.0	3.6	15.0	0.51	0.041	6.30	14.70	147	36	0.01	13.0	7.1	14.1
	860812	1108	52635	8.0	2.2	40.0	0.61	0.096	7.80	9.97	144	47	0.15	10.0	7.1	7.0
		1115	52636	8.0	2.0	45.0	0.67	0.120	8.80	8.57	136	47	0.20	8.3	7.1	6.4
	860815	0859	52663	1.5	7.4	6.0	0.92	0.120	4.20	24.30	239	50	0.28	26.0	7.1	13.3
		0905	52664	1.5	6.8	6.0	0.97	0.130	3.90	23.60	231	50	0.31	24.0	7.1	14.2

STN#	YYMMDD	TIME	SAMP#	IRON MG/L	MANGANESE MG/L	ALUMINUM MG/L	CHROMIUM MG/L	COPPER MG/L	ZINC MG/L
0176	860531	1026	16488	0.490	0.038	0.330	0.005	0.002	0.006
		1035	16489	0.480	0.036	0.330	0.005	0.002	0.005
		1040	16490	0.990	0.024	0.770	0.003	0.002	0.005
		1045	16491	1.000	0.024	0.800	0.003	0.002	0.005
	860602	1135	16534	0.520	0.054	0.320	0.008	0.002	0.007
		1140	16535	0.520	0.054	0.320	0 008	0.002	0.006
		1145	16536	0.400	0.011	0.300	0.001	0.001	0.003
		1150	16537	0.380	0.011	0.280	0.001	0.001	0.003
	860812	1024	52631	0.350	0.041	0.230	0.021	0.002	0.011
		1034	52632	0.350	0.040	0.230	0.022	0.003	0.012
		1041	52633	0.220	0.020	0.140	0.005	0.001	0.006
		1050	52634	0.200	0.018	0.130	0 004	0.001	0.004
	860815	0923	52665	0.390	0.049	0.220	0.013	0.002	0.012
		0927	52666	0.490	0.075	0.300	0.022	0.003	0.007
		0932	52667	0.170	0.009	0.130	0.001	0.002	0.001
		0937	52668	0.170	0.008	0.095	0.001	0.002	0.002
0653	860602	0846	16544	0.025	0.002	0.021	0.001	0.001	0.001
		0855	16545	0.030	0.002	0.019	ND	0.001	0.001
	860812	0958	52629	0.012	0.001	0.019	0.001	0.001	0.002
		1008	52630	0.013	0.001	0.022	0.001	0.001	0.001
	860815	0815	52661	0.027	0.002	0.018	ND	0.001	ND
		0820	52662	0.026	0.002	0.019	ND	0.001	0.006
0663	860531	1106	16492	0.085	0.005	0.058	0.001	0.001	0.002
		1110	16493	0.084	0.005	0.061	0.001	0.002	0.001
		1115	16494	0.091	0.005	0.061	0.001	0.001	0.002
		1120	16495	0.120	0.006	0.085	0.001	0.001	0.002
	860602	1155	16538	0.260	0.022	0.160	0.003	0.002	0.003
		1200	16539	0.260	0.022	0.160	0.003	0.001	0.003
		1205	16540	0.100	0.005	0.066	0.001	0.001	0.001
		1210	16541	0.120	0.007	0.070	0.001	0.001	0.002
	860812	1150	52637	0.052	0.005	0.040	0.001	0.001	0.001
		1155	52638	0.078	0.005	0.035	0.001	0.001	0.001
		1159	52639	0.051	0.005	0.037	ND	0.001	ND
		1205	52640	0.035	0.003	0.024	ND	0.002	ND
	860815	1002	52669	0.023	0.002	0.015	0.001	0.002	0.001
		1007	52670	0.024	0.002	0.018	ND	0.001	0.001
		1012	52671	0.041	0.003	0.028	ND	0.001	0.002
		1017	52672	M	M	M	M	M	M

STN#	YYMMDD	TIME	SAMP#	IRON MG/L	MANGANESE MG/L	ALUMINUM MG/L	CHROMIUM MG/L	COPPER MG/L	ZINC MG/L
0668	860531	0858	16482	0.056	0.004	0.046	0.001	0.001	0.001
		0905	16483	0.240	0.005	0.048	— 0.001	0.001	0.001
		0910	16484	0.068	0.004	0.050	0.001	0.001	0.001
		0915	16485	0.130	0.004	0.050	0.001	0.001	0.001
	860602	1035	16528	0.075	0.004	0.060	0.001	ND	0.002
		1040	16529	0.068	0.004	0.051	0.001	0.001	0.001
		1045	16530	0.062	0.004	0.047	0.001	ND	0.001
		1050	16531	0.057	0.003	0.045	0.001	ND	0.001
	860812	1326	52645	0.015	0.001	0.017	ND	0.001	ND
		1330	52646	0.014	0.001	0.018	ND	0.001	ND
		1335	52647	0.016	0.002	0.023	ND	0.001	ND
		1340	52648	0.016	0.001	0.024	ND	0.001	ND
	860815	1116	52677	0.017	0.001	0.018	ND	0.001	0.020
		1121	52678	0.016	0.001	0.023	0.001	0.001	0.020
		1126	52679	0.026	0.001	0.039	0.001	0.002	0.020
		1131	52680	0.030	0.001	0.023	ND	ND	ND
0671	860530	1105	16475	0.300	0.026	0.120	3.400	0.002	0.003
		1110	16476	0.430	0.027	0.200	0.006	0.002	0.003
		1115	16477	0.680	0.032	0.240	0.002	0.001	0.003
		1120	16478	0.520	0.027	0.210	0.002	0.001	0.003
	860602	0955	16523	0.530	0.051	0.270	0.008	0.002	0.004
		1000	16524	0.510	0.050	0.280	0.008	0.001	0.005
		1005	16525	0.280	0.016	0.150	0.002	0.002	0.003
		1010	16526	0.460	0.023	0.280	0.002	0.001	0.003
	860812	1229	52641	0.240	0.029	0.110	0.009	0.001	0.031
		1234	52642	0.280	0.028	0.140	0.007	0.001	0.003
		1240	52643	2.100	0.025	0.140	0.004	0.002	0.001
		1245	52644	0.230	0.016	0.140	0.004	0.002	0.002
	860815	1040	52673	0.360	0.055	0.170	0.014	0.002	0.008
		1045	52674	0.340	0.053	0.180	0.013	0.002	0.014
		1050	52675	0.120	0.009	0.065	ND	0.001	0.018
		1055	52676	0.110	0.008	0.056	ND	0.001	0.004

STN#	YYMMDD	TIME	SAMP#	IRON MG/L	MANGANESE MG/L	ALUMINUM MG/L	CHROMIUM MG/L	COPPER MG/L	ZINC MG/L
0677	860530	1020	16471	0.490	0.033	0.290	0.004	0.002	0.019
		1025	16472	0.480	0.034	0.300	0.004	0.002	0.014
		1030	16473	0.200	0.006	0.140	0.001	0.002	0.002
		1035	16474	0.160	0.005	0.120	ND	0.001	0.001
	860602	0916	16519	0.540	0.048	0.250	0.007	0.003	0.004
		0920	16520	0.550	0.047	0.260	0.007	0.002	0.005
		0925	16521	0.220	0.007	0.170	0.001	0.001	0.002
		0930	16522	0.150	0.005	0.110	0.001	0.001	0.001
	860812	1420	52649	1.700	0.061	0.098	0.002	0.004	0.003
		1424	52650	2.000	0.070	0.094	0.003	0.005	0.004
		1428	52651	0.380	0.016	0.150	0.001	0.002	ND
		1432	52652	M	M	M	M	M	M
	860815	1149	52681	0.440	0.043	0.098	0.007	0.002	ND
		1154	52682	0.480	0.049	0.110	0.008	0.002	ND
		1159	52683	0.067	0.004	0.048	ND	0.001	ND
		1204	52684	0.066	0.004	0.053	ND	ND	0.006
0791	860530	0852	16469	0.023	0.002	0.026	0.001	0.001	0.022
		0915	16470	0.018	0.002	0.022	0.001	0.001	0.019
	860602	0747	16517	0.013	0.001	0.014	ND	0.001	0.001
	860812	0905	52625	0.012	0.001	0.018	ND	ND	0.007
		0910	52626	0.012	0.001	0.019	ND	ND	0.001
	860815	0745	52657	0.012	0.001	0.011	ND	0.001	0.001
		0750	52658	0.011	0.001	0.010	ND	0.001	0.001
0795	860602	0824	16542	0.044	0.002	0.026	0.001	0.002	0.002
		0830	16543	0.038	0.002	0.023	0.001	0.001	0.002
	860812	0941	52627	0.014	0.001	0.023	ND	0.001	0.001
		0951	52628	0.016	0.001	0.021	ND	ND	0.007
	860815	0814	52659	0.015	0.002	0.014	ND	0.001	ND
		0824	52660	0.025	0.002	0.010	ND	0.001	0.003
0802	860531	0957	16486	0.800	0.049	0.620	0.011	0.003	0.008
		1005	16487	0.590	0.045	0.430	0.009	0.002	0.006
	860602	1110	16532	0.850	0.069	0.560	0.010	0.002	0.007
		1115	16533	0.930	0.071	0.640	0.011	0.003	0.007
	860812	1108	52635	2.300	0.053	1.700	0.014	0.005	0.011
		1115	52636	2.000	0.049	1.600	0.011	0.005	0.011
	860815	0859	52663	0.480	0.066	0.220	0.021	0.003	0.021
		0905	52664	0.520	0.067	0.230	0.018	0.003	0.012

APPENDIX C: SEDIMENT QUALITY TESTS

Physical Parameters:	Particle Size, Solvent Extractable, Percentage Loss on Ignition
Nutrients:	Total Phosphorus, Total Kjeldahl Nitrogen, Total Organic Carbon
Trace Metals: (unfiltered total)	Iron, Manganese, Aluminum, Arsenic, Cadmium, Chromium, Copper, Mercury, Nickel, Lead, Zinc
Organochlorines:	Total PCBs, Hexachlorobenzene, Heptachlor, Heptachlor Epoxide, Aldrin, Dieldrin, Endrin, Mirex, alpha BHC, beta BHC, gamma BHC (lindane), alpha Chlordane, gamma Chlordane, Oxychlordane, o,p-DDT, p,p-DDT, p,p-DDD, p,p-DDE, Methoxychlor (DMDT), Endosulphan I, Endosulphan II, Endosulphan Sulphate, Octachlorostyrene